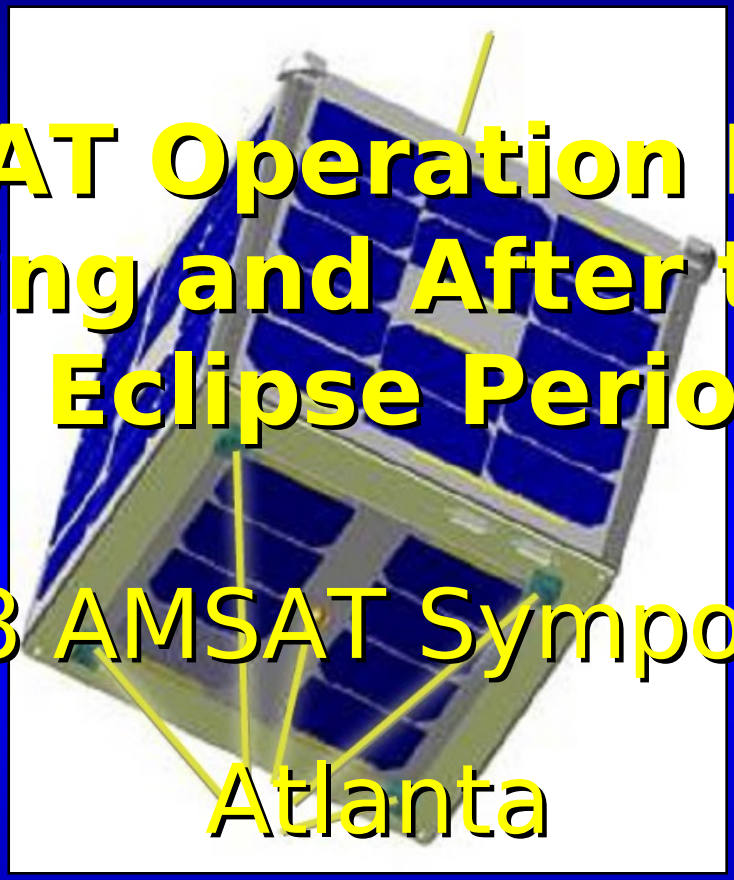
AMSAT Operation Before, During and After the No Eclipse Period



2008 AMSAT Symposium

Atlanta

Gould Smith, WA4SXM

AMSAT VP User Services

AO-51 Command Station

AO-51 (Echo) History

- **Improved Microsat (9.5” cube)**
- **Built by SpaceQuest ,Ltd**
- **70cm and S band FM downlinks**
- **2M FM & SQRX receivers**
- **9600/38k4 bps AX.25 FSK Digital**
- **Multiple simultaneous mode combinations**
- **$500k to build, $110k launch**

Sample AO-51 Operations in 2008

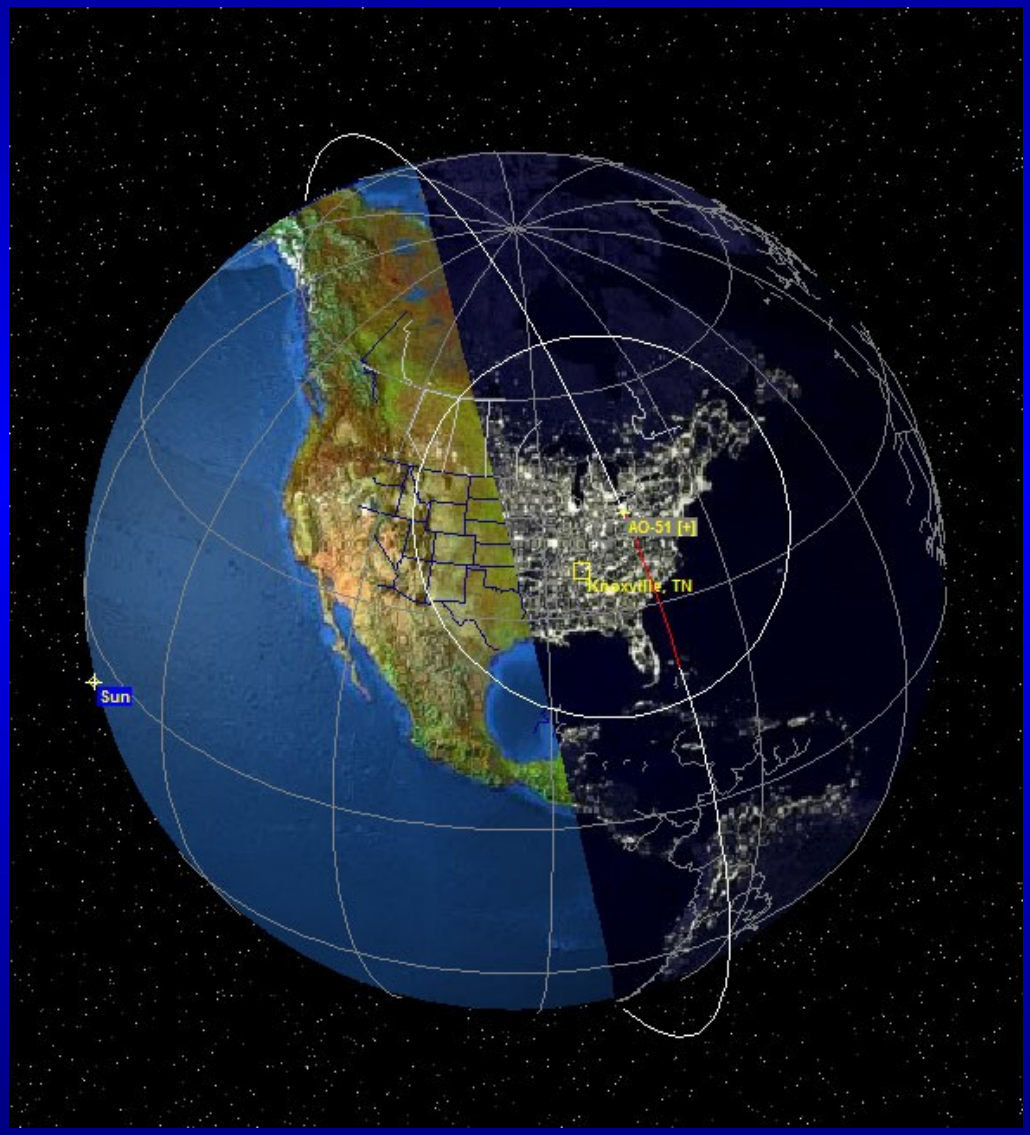
- **V/US FM repeater**
- **V/U FM repeater and L/U digital BB ‘normal’**
- **V/U and V/U FM repeater**
- **L/US FM repeater**
- **L/S FM repeater & V/U FM repeater**
- **V/U SSB/FM repeater & V/U FM repeater**
- **L/U SSB/FM repeater & V/U FM repeater**
- **V/S FM repeater**

ao51-modes@amsat.org

Changes to AO-51 Over the Last Four Years

- Orbit & Eclipses
- Battery Voltages
- Temperatures
- Solar Array Current
- Spin Rate

AO-51 Orbit



Sun-synchronous

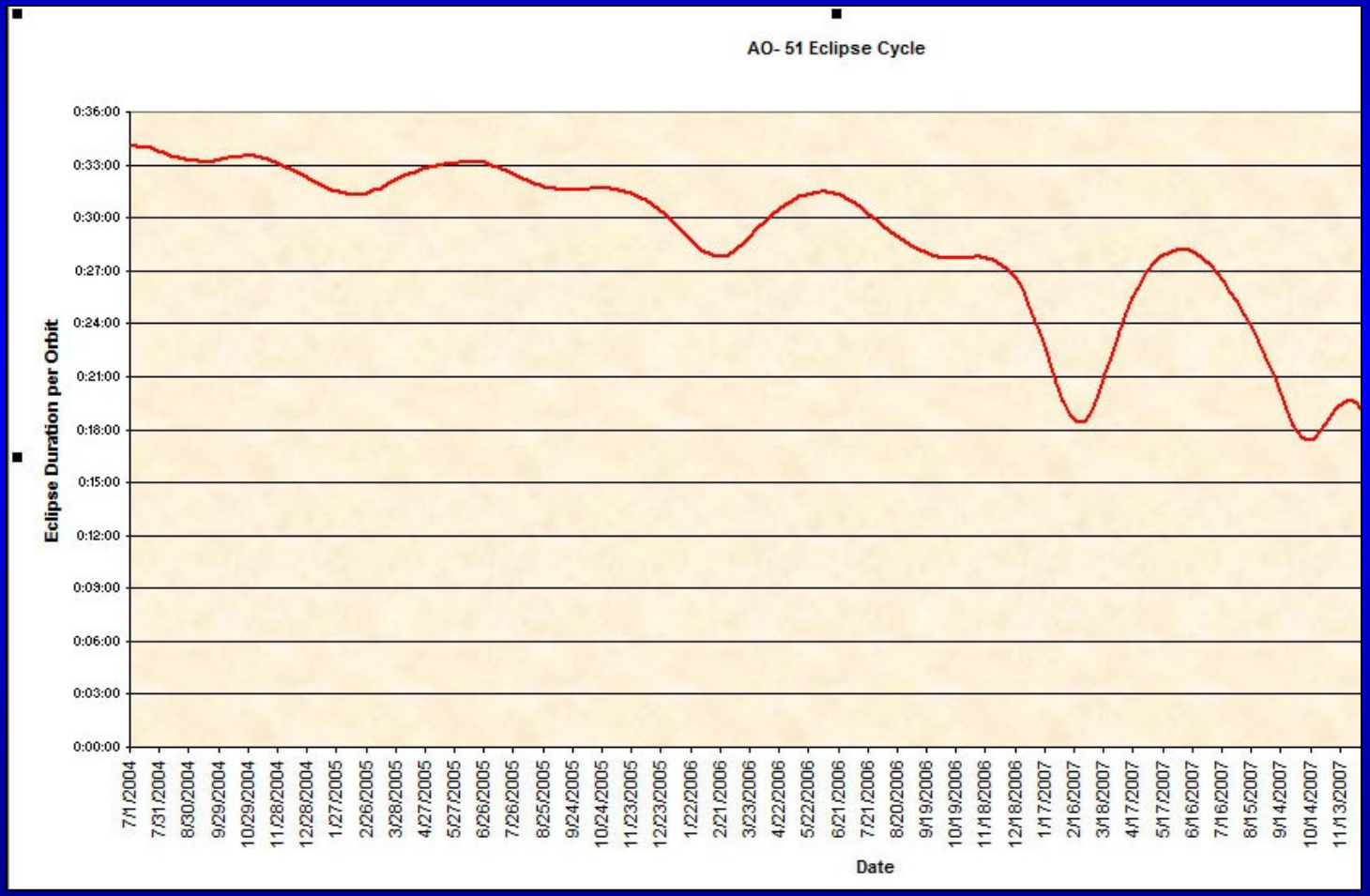
98.72º inclination

696 - 817 km altitude

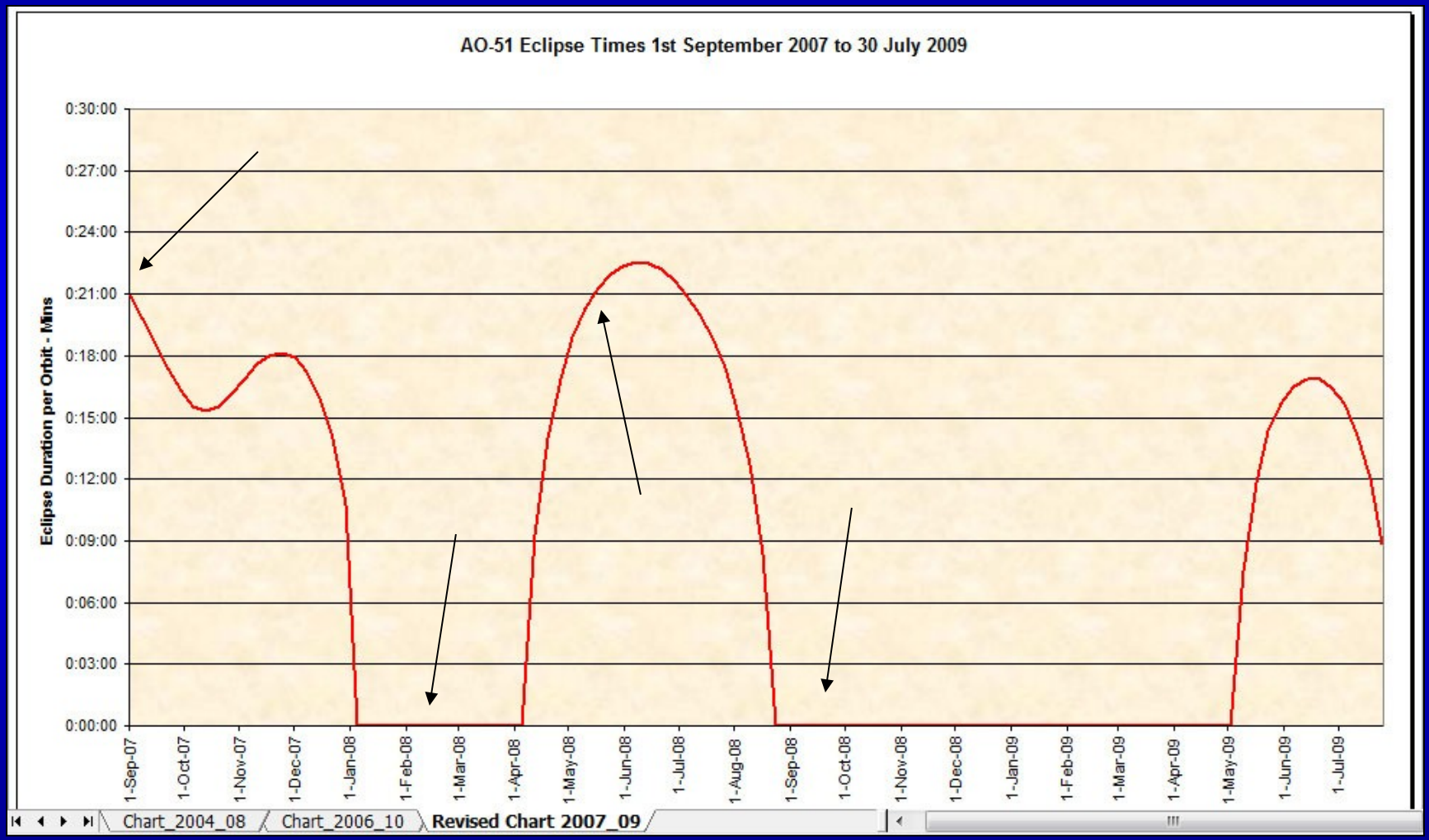
~98 min orbit

No eclipse period

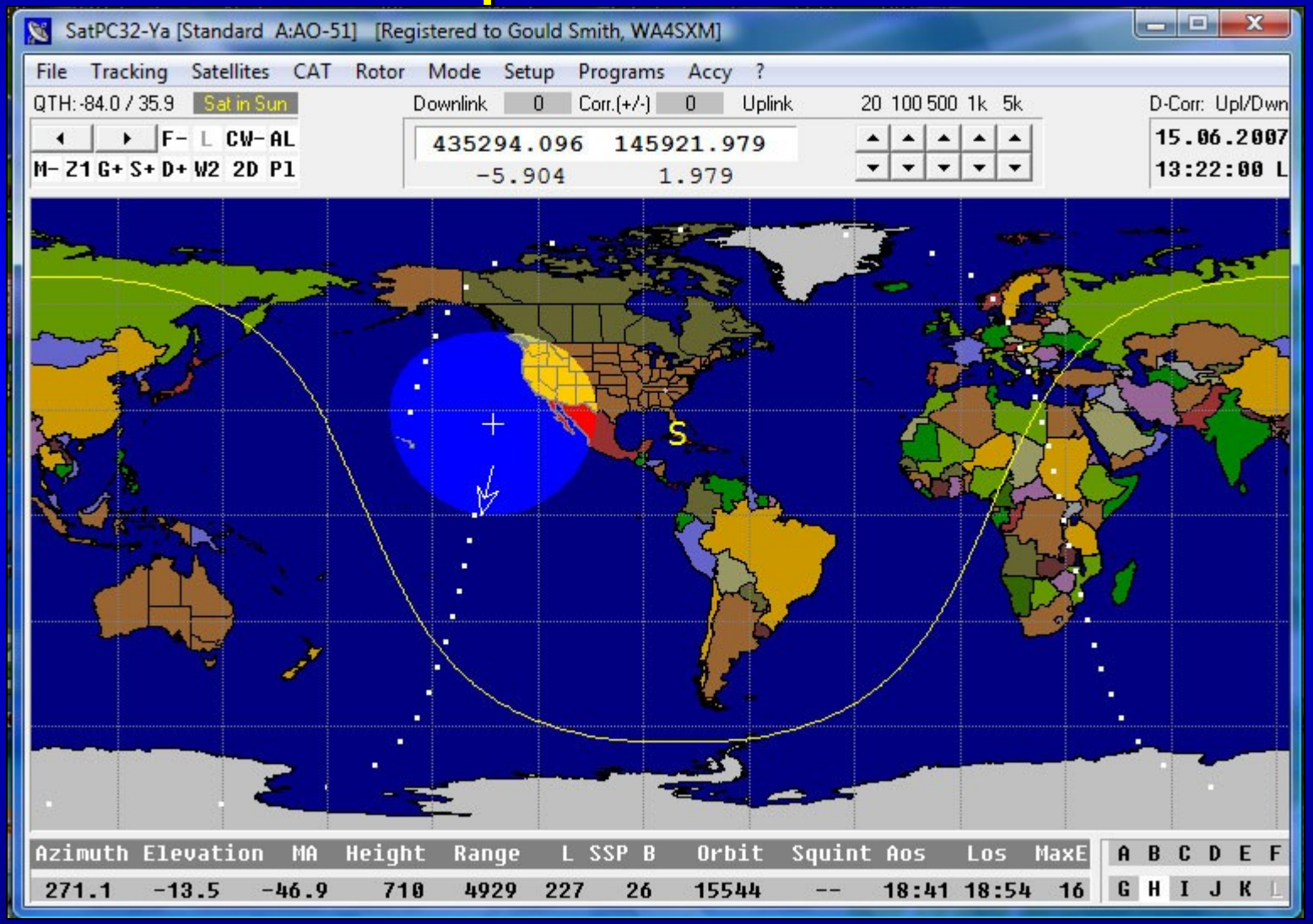
AO-51 Eclipse Times 2004 - 2007



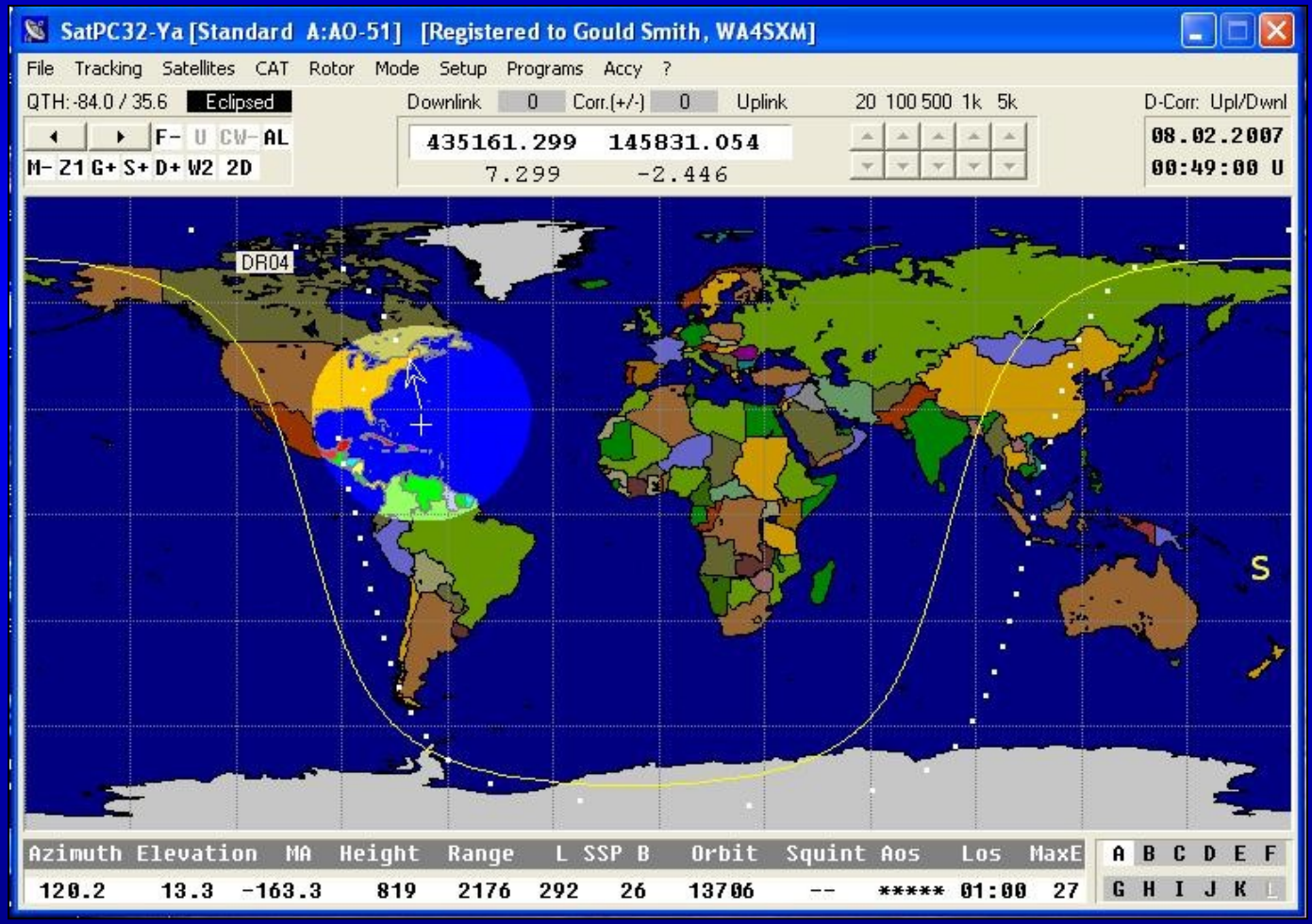
AO-51 Eclipse Times 2007-2009



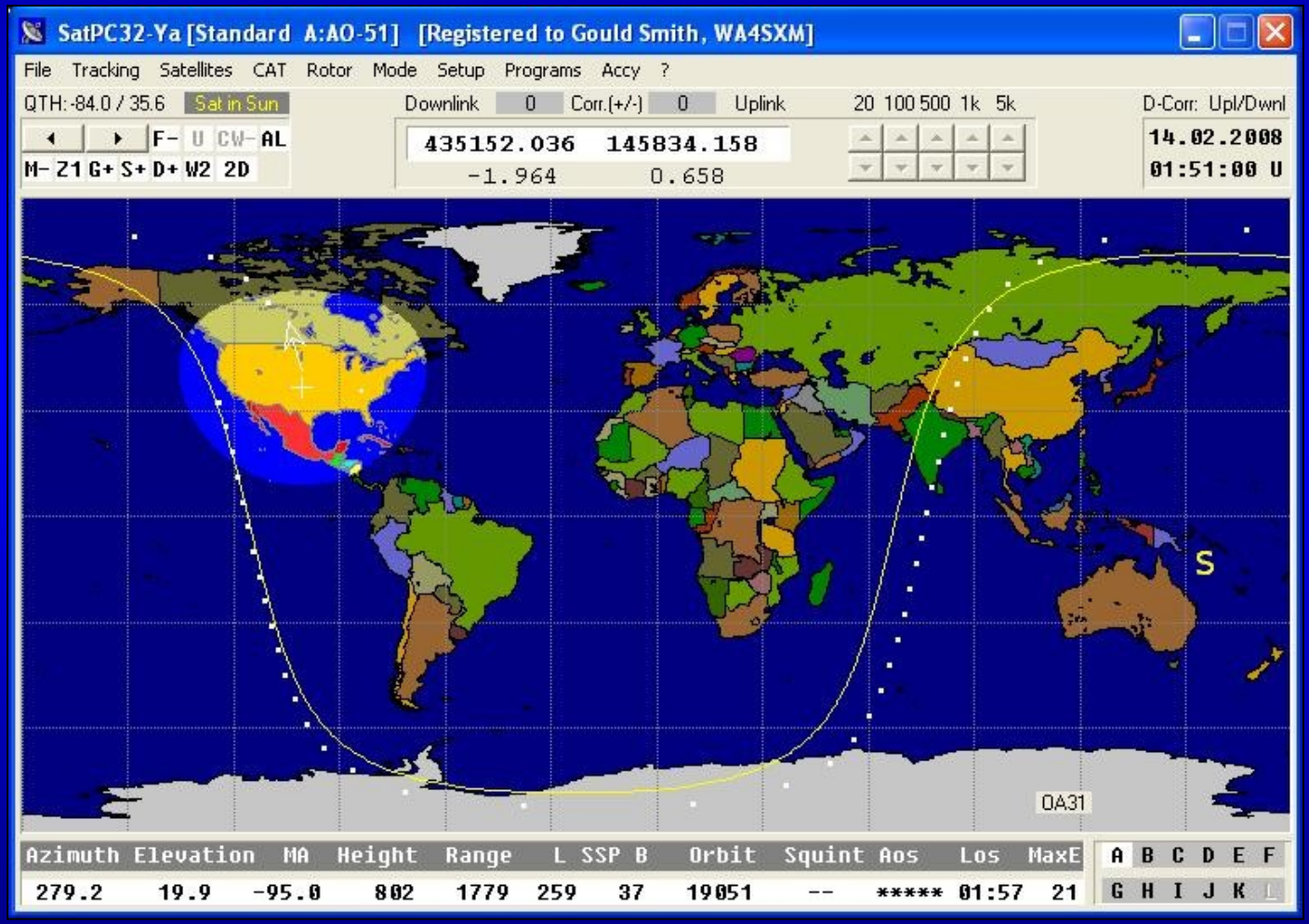
AO-51 Orbit 15 Jun 07
eclipse ~28:30


SatPC32-Ya [Standard A:AO-51] [Registered to Gould Smith, WA4SXM]
File Tracking Satellites CAT Rotor Mode Setup Programs Accy ?
QTH: -84.0 / 35.9
Sat in Sun
Downlink 0 Corr.(+/-) 0 Uplink
20 100 500 1k 5k
D-Corr: Upl/Dwn
F- L CW- AL
M- Z1 G+ S+ D+ W2 2D P1
435294.096 145921.979
-5.904 1.979
15.06.2007
13:22:00 L
S
Azimuth Elevation MA Height Range L SSP B Orbit Squint Aos Los MaxE
271.1 -13.5 -46.9 710 4929 227 26 15544 -- 18:41 18:54 16
A B C D E F
G H I J K L

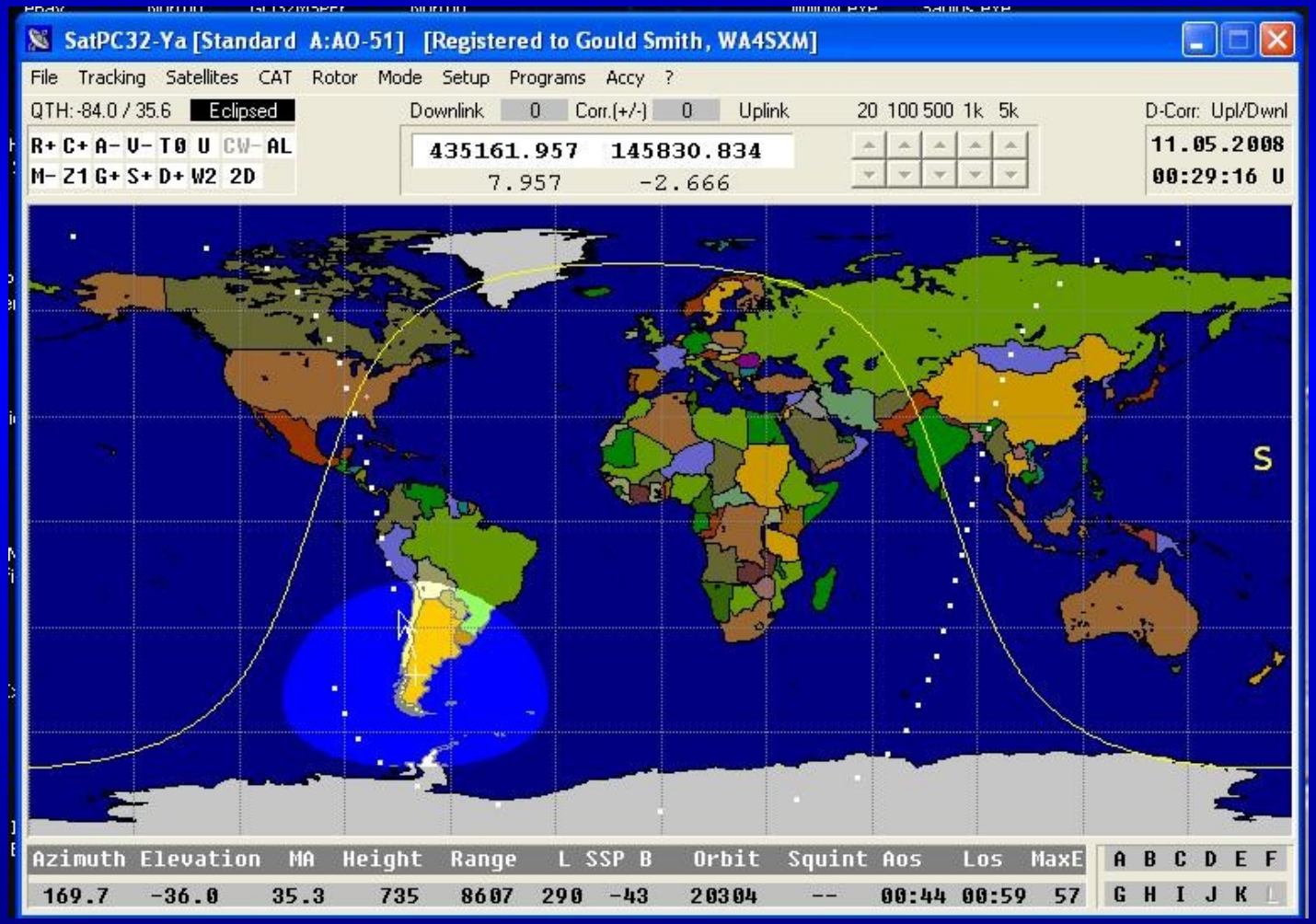
AO-51 Orbit 2 Aug 07 eclipse 24:30


SatPC32-Ya [Standard A:AO-51] [Registered to Gould Smith, WA4SXM]
File Tracking Satellites CAT Rotor Mode Setup Programs Accy ?
QTH:-84.0 / 35.6 Eclipsed
Downlink 0 Corr.(+/-) 0 Uplink
20 100 500 1k 5k
D-Corr: Upl/Dwnl
435161.299 145831.054
7.299 -2.446
08.02.2007
00:49:00 U
DR04
Azimuth Elevation MA Height Range L SSP B Orbit Squint Aos Los MaxE
120.2 13.3 -163.3 819 2176 292 26 13706 -- ***** 01:00 27

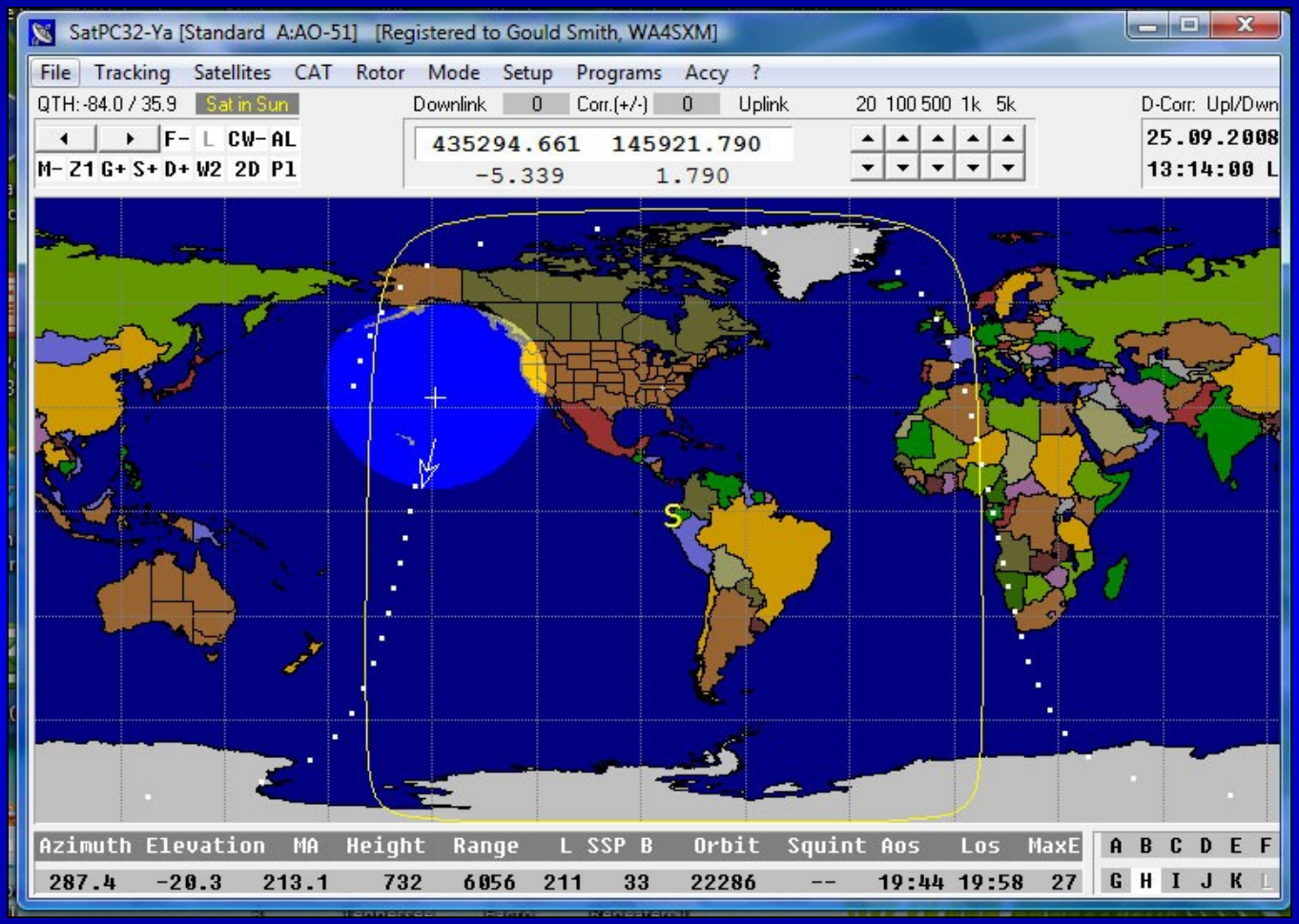
AO-51 Orbit 14 Feb 08
no eclipse


SatPC32-Ya [Standard A:AO-51] [Registered to Gould Smith, WA4SXM]
File Tracking Satellites CAT Rotor Mode Setup Programs Accy ?
QTH: -84.0 / 35.6 Sat in Sun
Downlink 0 Corr.(+/-) 0 Uplink
20 100 500 1k 5k
D-Corr: Upl/Dwnl
435152.036 145834.158
-1.964 0.658
14.02.2008
01:51:00 U
OA31
Azimuth Elevation MA Height Range L SSP B Orbit Squint Aos Los MaxE
279.2 19.9 -95.0 802 1779 259 37 19051 -- ***** 01:57 21

AO-51 Orbit 11 May 08 eclipse ~21:00


SatPC32-Ya [Standard A:AO-51] [Registered to Gould Smith, WA4SXM]
File Tracking Satellites CAT Rotor Mode Setup Programs Accy ?
QTH:-84.0 / 35.6 Eclipsed
Downlink 0 Corr.(+/-) 0 Uplink
20 100 500 1k 5k
D-Corr: Upl/Dwnl
R+ C+ A- V- T0 U CW- AL
M- Z1 G+ S+ D+ W2 2D
435161.957 145830.834
7.957 -2.666
11.05.2008
00:29:16 U
S
Azimuth Elevation MA Height Range L SSP B Orbit Squint Aos Los MaxE
169.7 -36.0 35.3 735 8607 290 -43 20304 -- 00:44 00:59 57
A B C D E F
G H I J K L

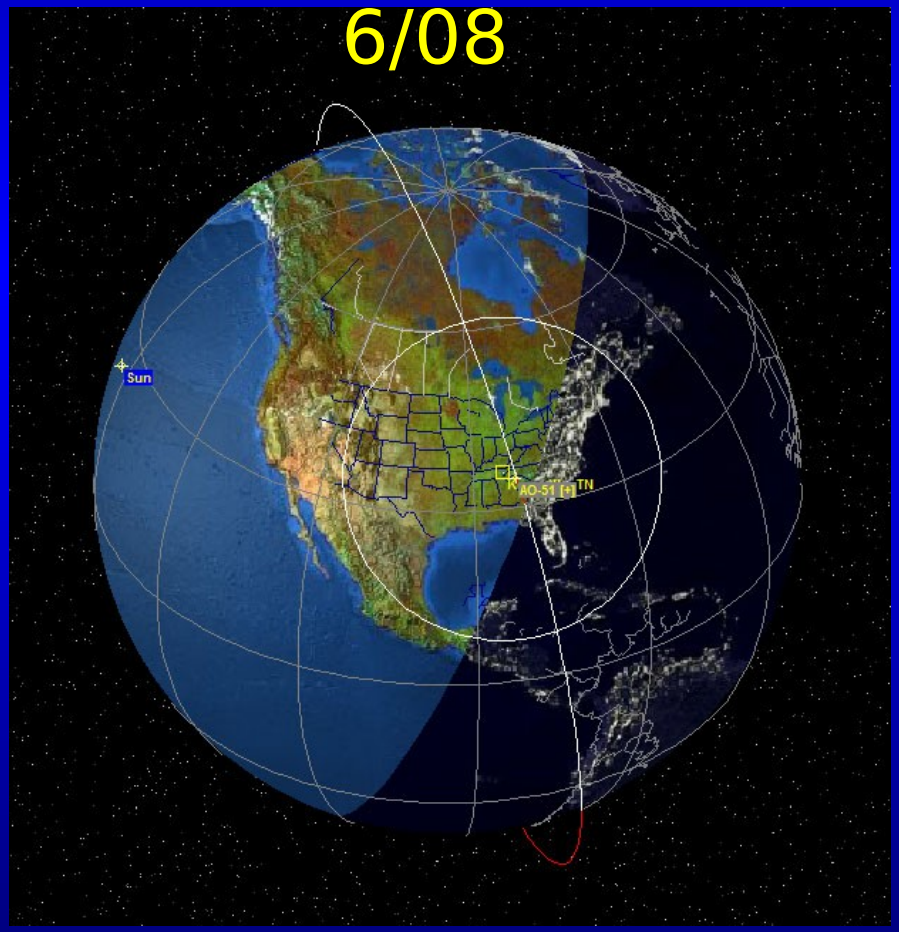
A0-51 Satellite Orbit


SatPC32-Ya [Standard A:AO-51] [Registered to Gould Smith, WA4SXM]
File Tracking Satellites CAT Rotor Mode Setup Programs Accy ?
QTH: -84.0 / 35.9
Sat in Sun
Downlink 0 Corr.(+/-) 0 Uplink
20 100 500 1k 5k
D-Corr: Upl/Dwn
435294.661 145921.790
-5.339 1.790
25.09.2008
13:14:00 L
Azimuth Elevation MA Height Range L SSP B Orbit Squint Aos Los MaxE
287.4 -20.3 213.1 732 6056 211 33 22286 -- 19:44 19:58 27
A B C D E F
G H I J K L

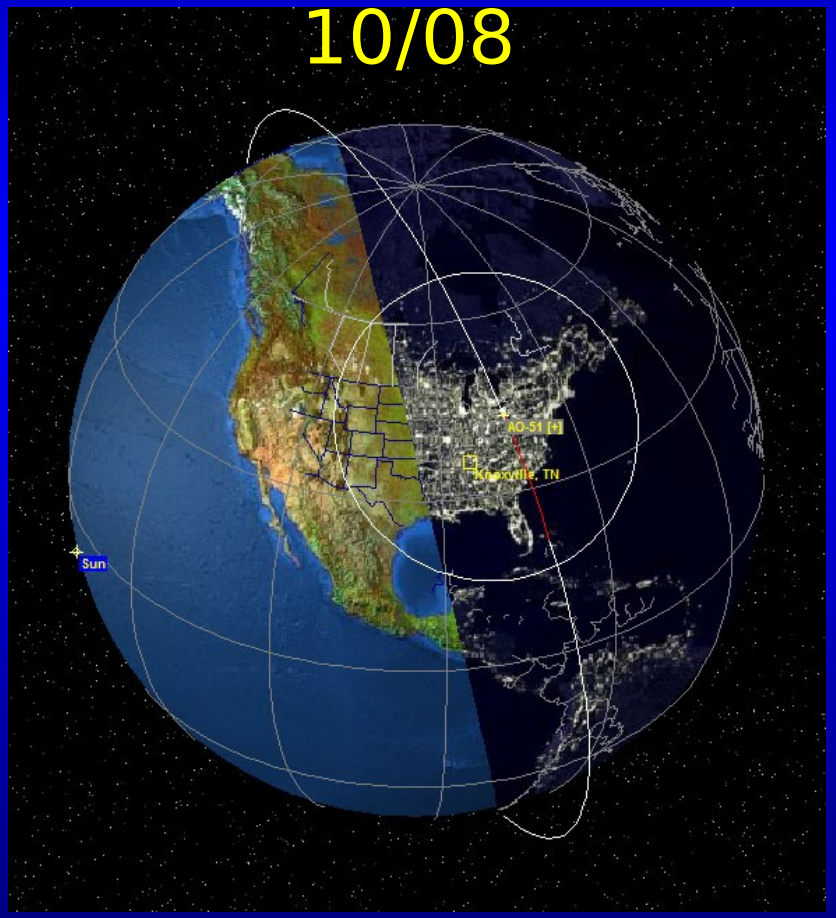
Close to autumnal equinox

A0-51 Satellite Orbit

During Orbital Eclipse Period 6/08

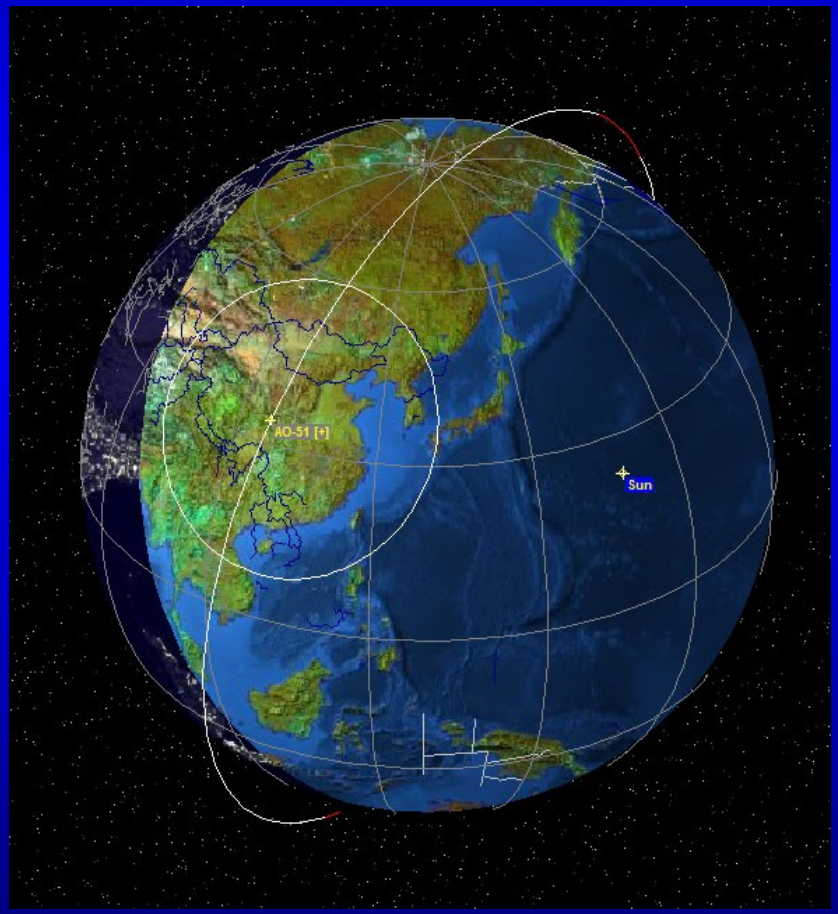


During Orbital No Eclipse Period 10/08

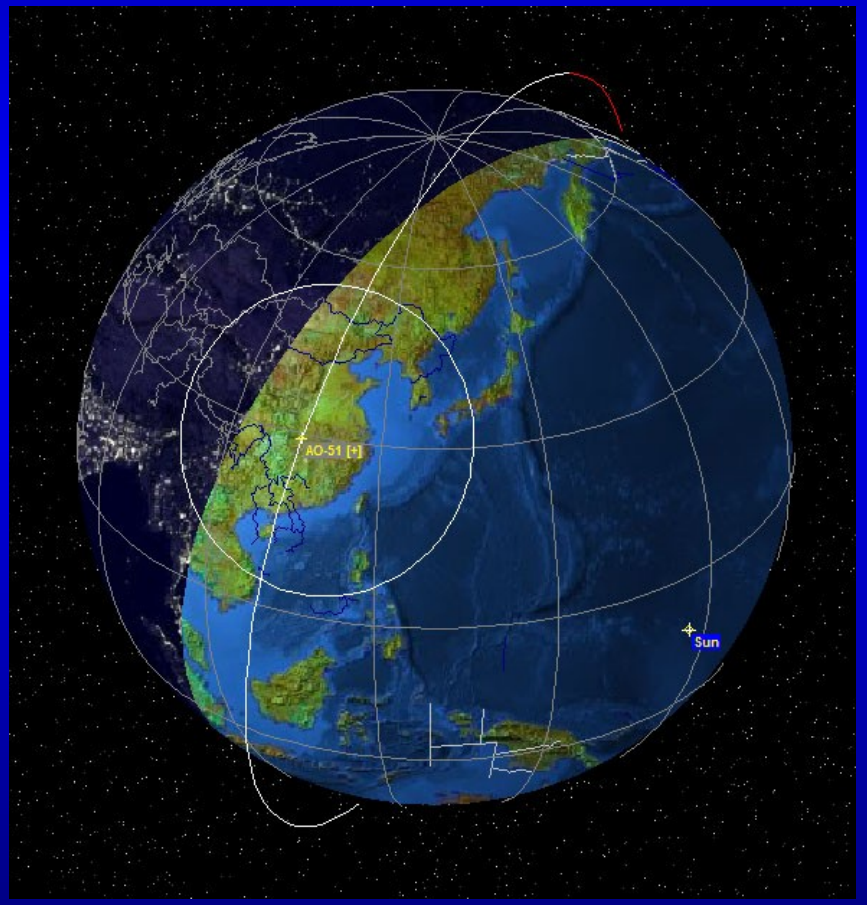


A0-51 Satellite Orbit Flip side

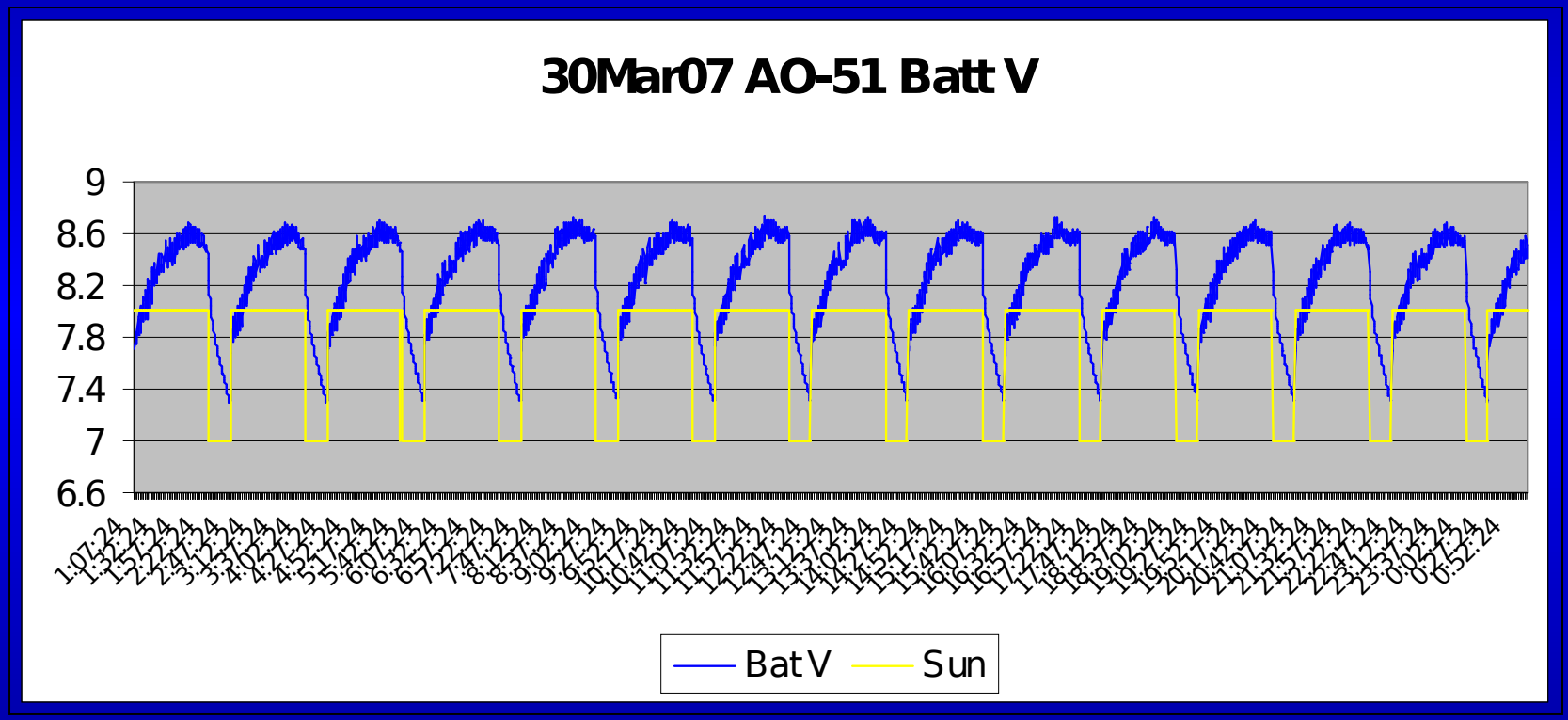
During Orbital Eclipse Period



During Orbital No Eclipse Period

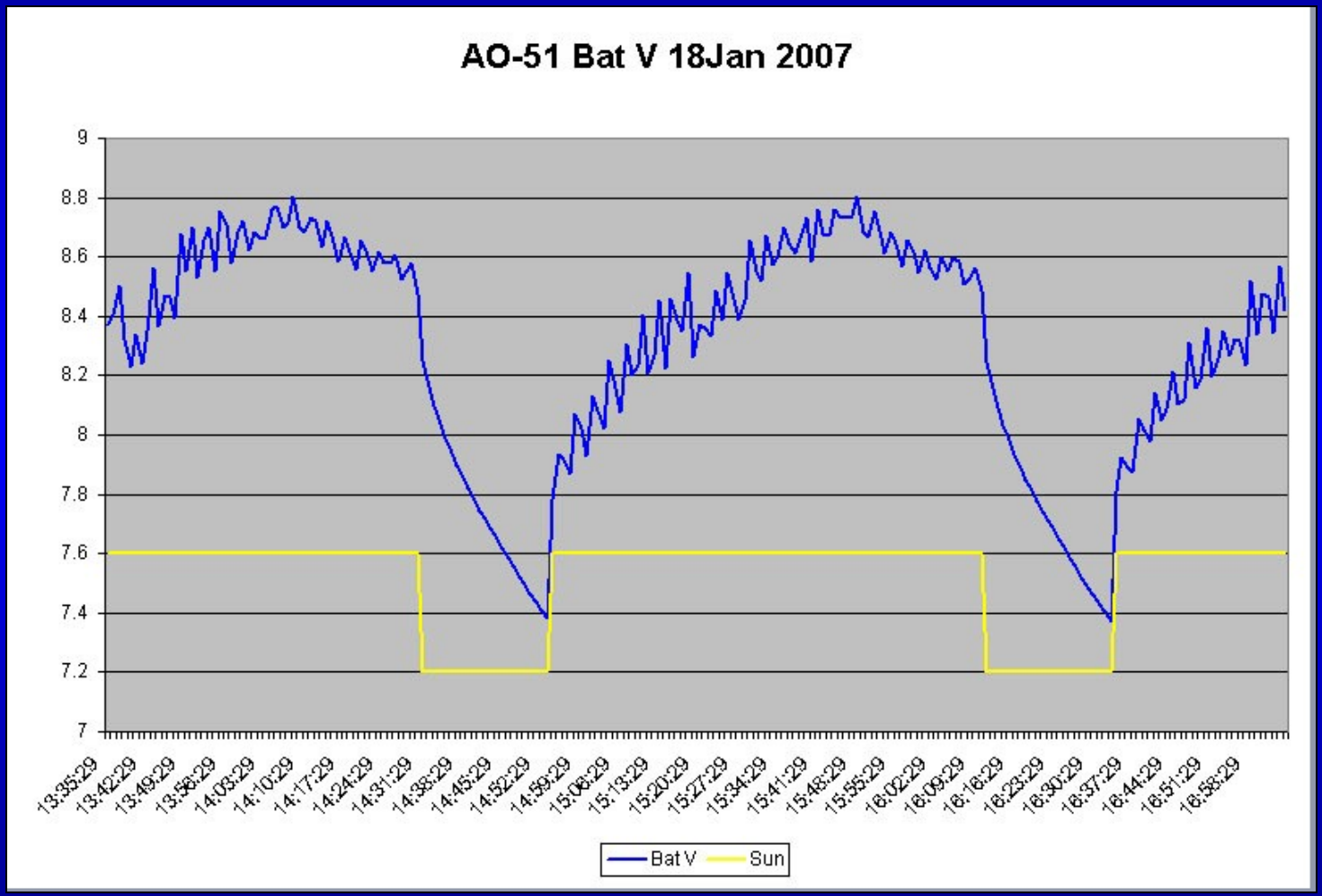


AO-51 Transmit Power and Eclipse Time

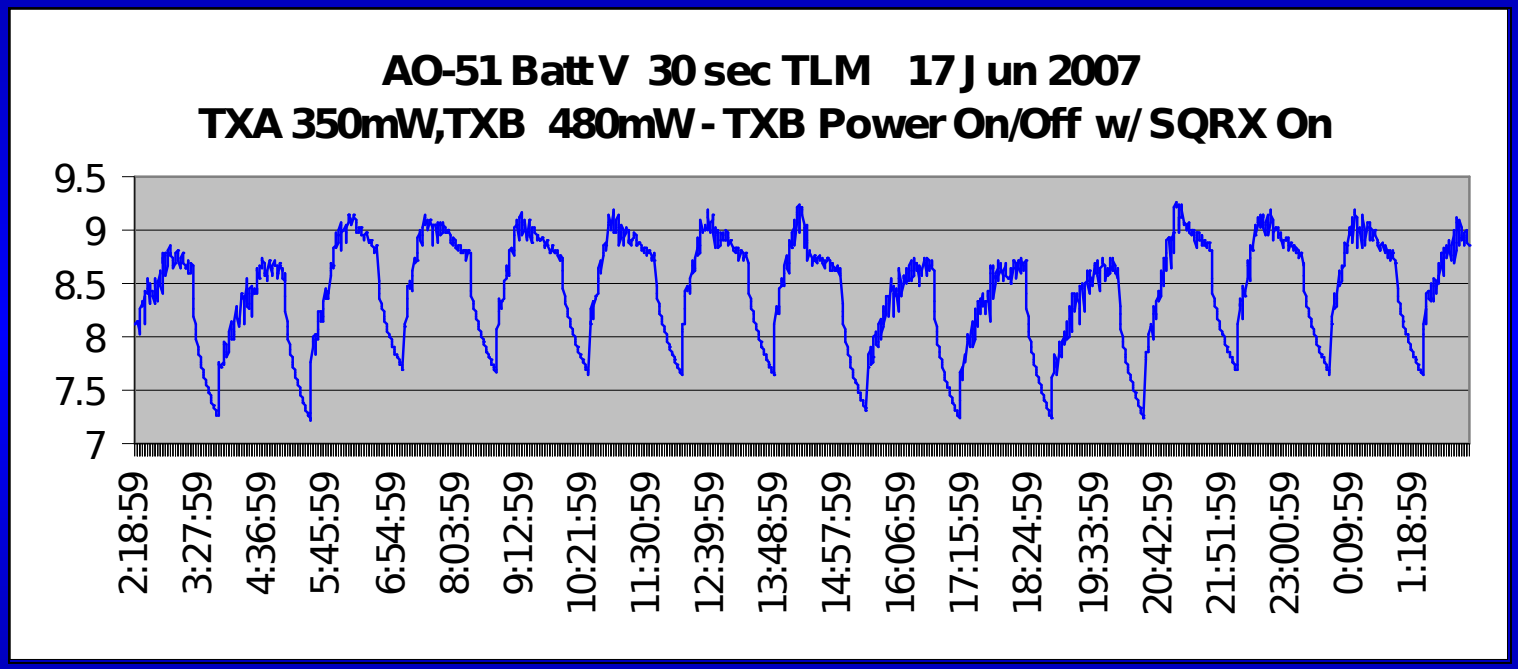


We generally use about 1W TX power during eclipse operation

AO-51 Solar Power & Eclipse

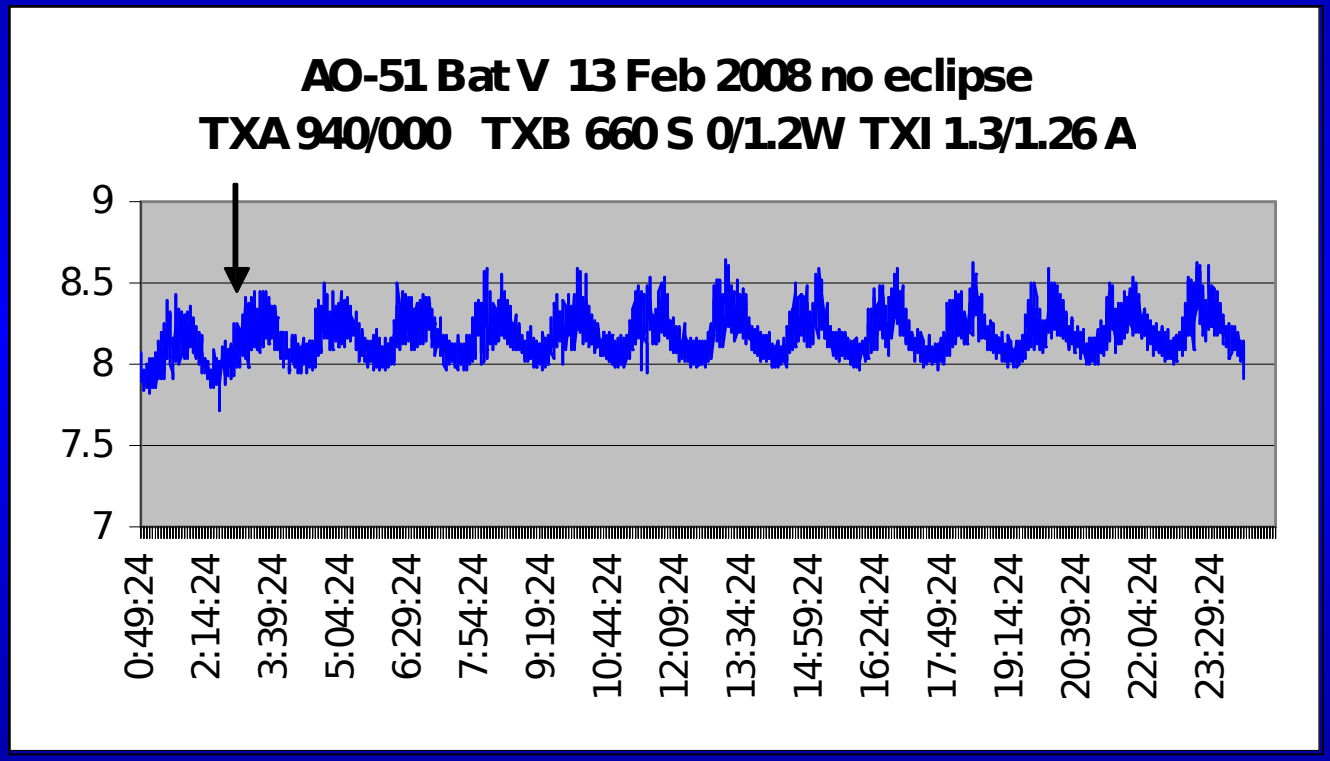


AO-51 Battery Voltage Changes With Power Changes



TX I changed from 880mA to 440mA

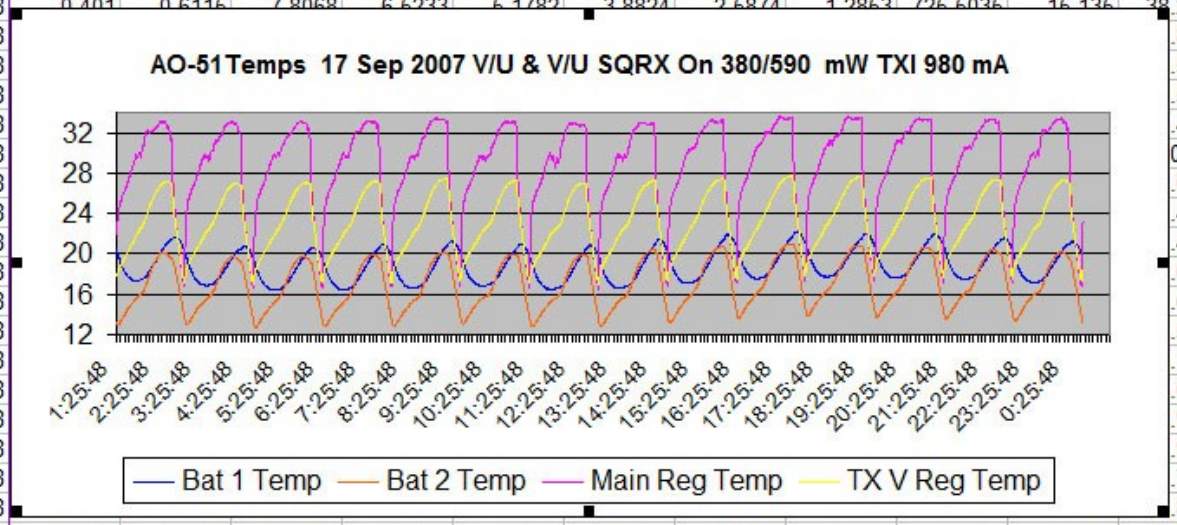
AO-51 Battery Voltage During No Eclipse Time



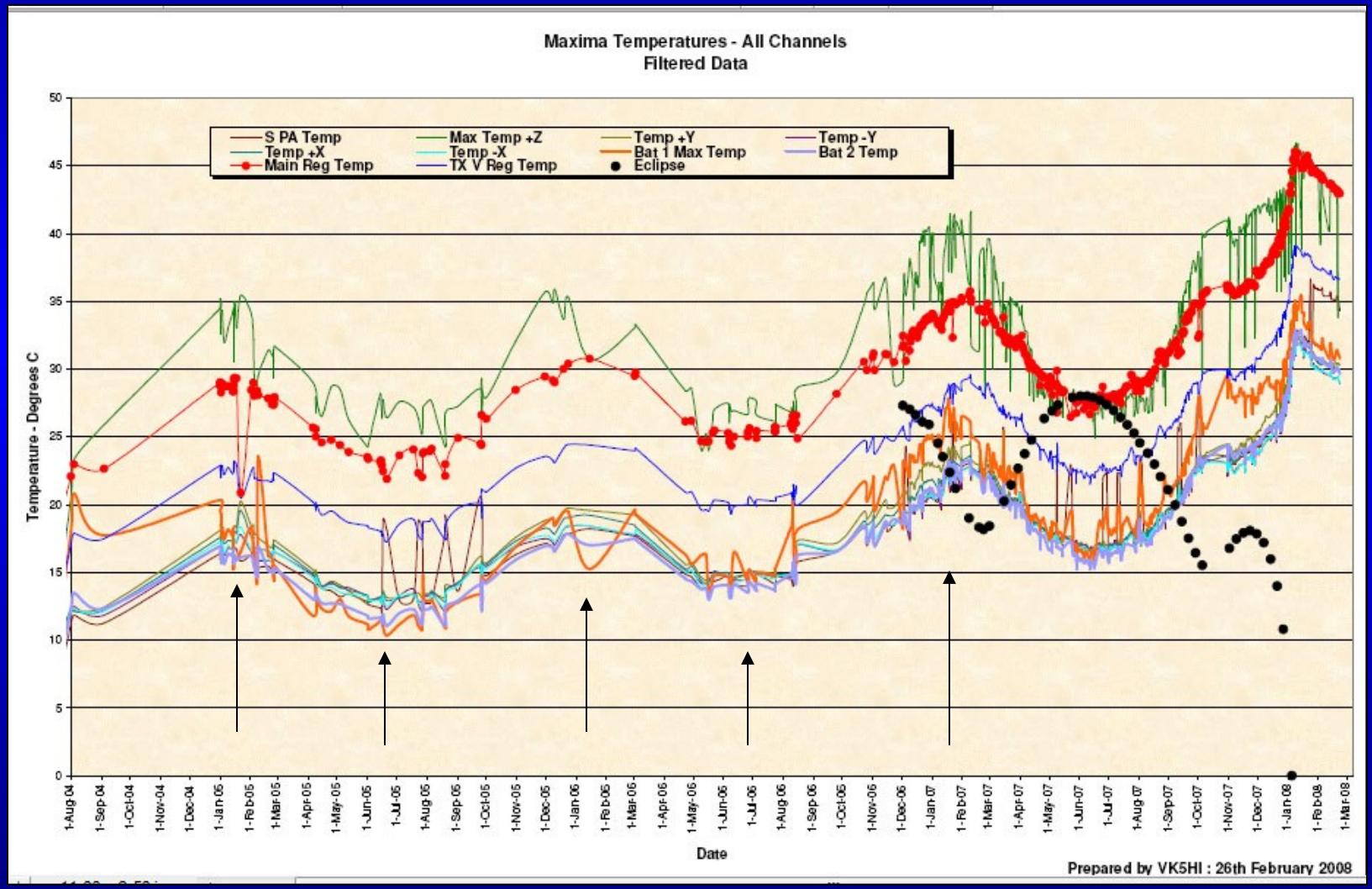
AO-51 Temperatures

Wd091700

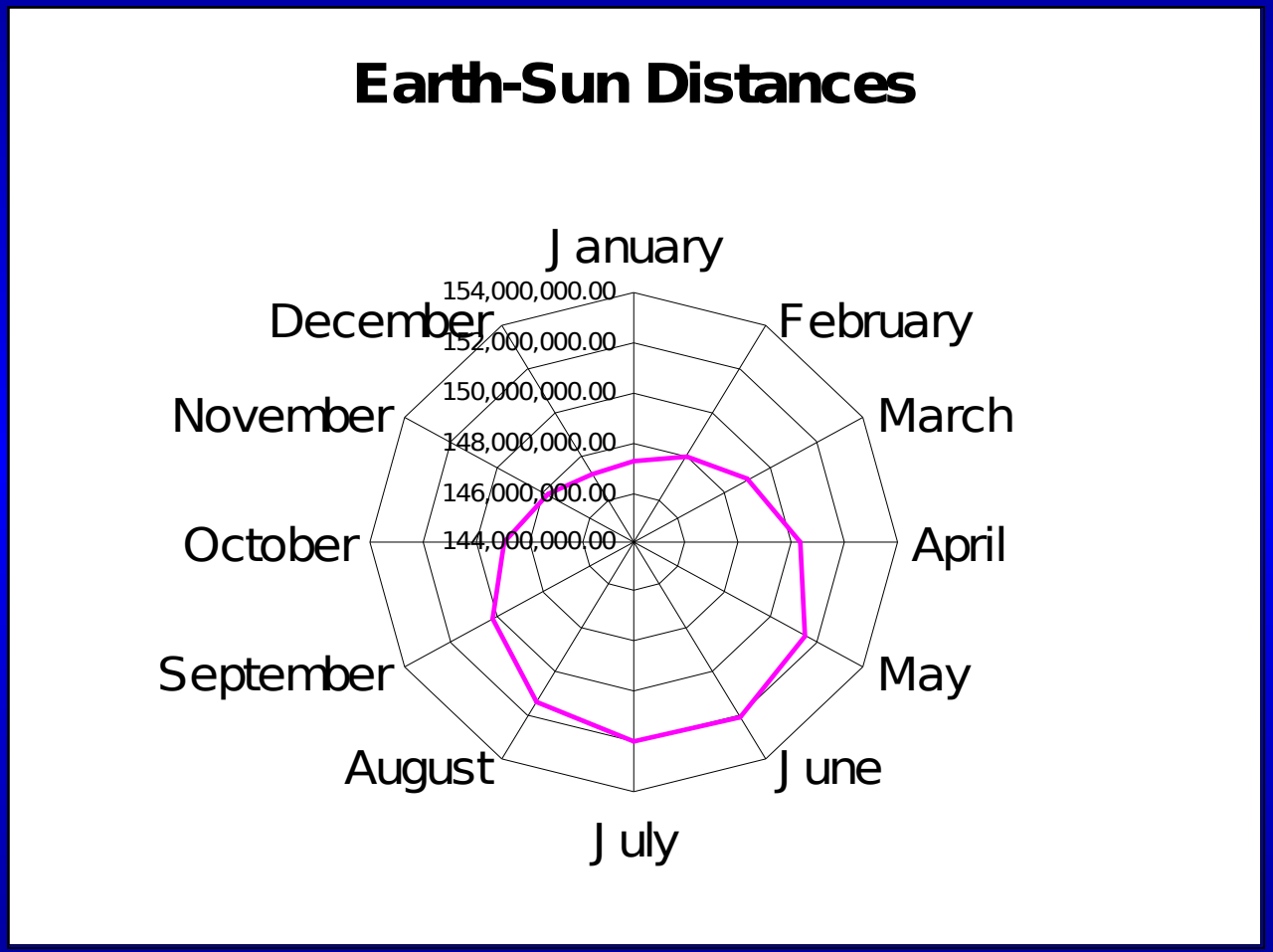
	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Echo Time	TX A Powe	TX B Powe	Bat V	Cell 5 V	Cell 4 V	Cell 3 V	Cell 2 V	Cell 1 V	Total Array	Total Array	+X I	-X I
2	1:25:48	0.401	0.6298	7.9166	6.613	5.2541	3.942	2.6291	1.3094	981.1517	15.147	465.4788	39.5
3	1:26:18	0.401	0.6298	7.7824	6.5127	5.1655	3.8761	2.5825	1.2853	761.2585	15.135	645.9507	40.5
4	1:26:48	0.401	0.6115	7.9471	6.6447	5.2794	3.9577	2.6438	1.3167	993.666	15.147	475.0784	39.5
5	1:27:18	0.401	0.6115	7.8068	6.5233	5.1782	3.8824	2.5874	1.2853	725.5035	15.135	38.2979	41.5
6	1:27:48											.8185	424.2
7	1:28:18											.5382	718.0
8	1:28:48											.5382	632.9
9	1:29:18											.4981	285.8
10	1:29:48											0.536	32.6
11	1:30:18											.0784	31.6
12	1:30:48											.4702	29.6
13	1:31:18											.4777	27.6
14	1:31:48											.0176	24.7
15	1:32:18											.6572	445.0
16	1:32:48											.5371	716.0
17	1:33:18											.1378	638.9
18	1:33:48											.0977	230.4
19	1:34:18											.9311	12.
20	1:34:48											.9139	13.
21	1:35:18											.7094	11.8
22	1:35:48											.8381	10.8
23	1:36:18	0.3872	0.5935	7.9471	6.6499	5.2794	3.9577	2.6365	1.307	752.3197	15.135	63.2568	8.8
24	1:36:48	0.3872	0.5935	8.0568	6.7396	5.3554	4.0173	2.6831	1.3335	1049.086	15.159	59.417	420.3
25	1:37:18	0.3872	0.596	8.0812	6.7555	5.368	4.0205	2.6831	1.3311	859.5847	15.147	59.417	699.2
26	1:37:48	0.3872	0.5935	7.9897	6.6816	5.3132	3.986	2.6634	1.3215	995.4537	15.159	58.457	626.
27	1:38:18	0.3872	0.5935	8.1422	6.8135	5.4102	4.0582	2.7051	1.3432	954.3355	15.147	40.2178	209.6
28	1:38:48	0.385	0.596	7.9715	6.671	5.3005	3.9765	2.6536	1.3167	936.458	15.147	197.6508	-3.9
29	1:39:18	0.3872	0.5935	8.2154	6.8716	5.4608	4.0958	2.7346	1.3577	1034.784	15.159	620.0319	-3.9



AO-51 Lifetime Temperatures

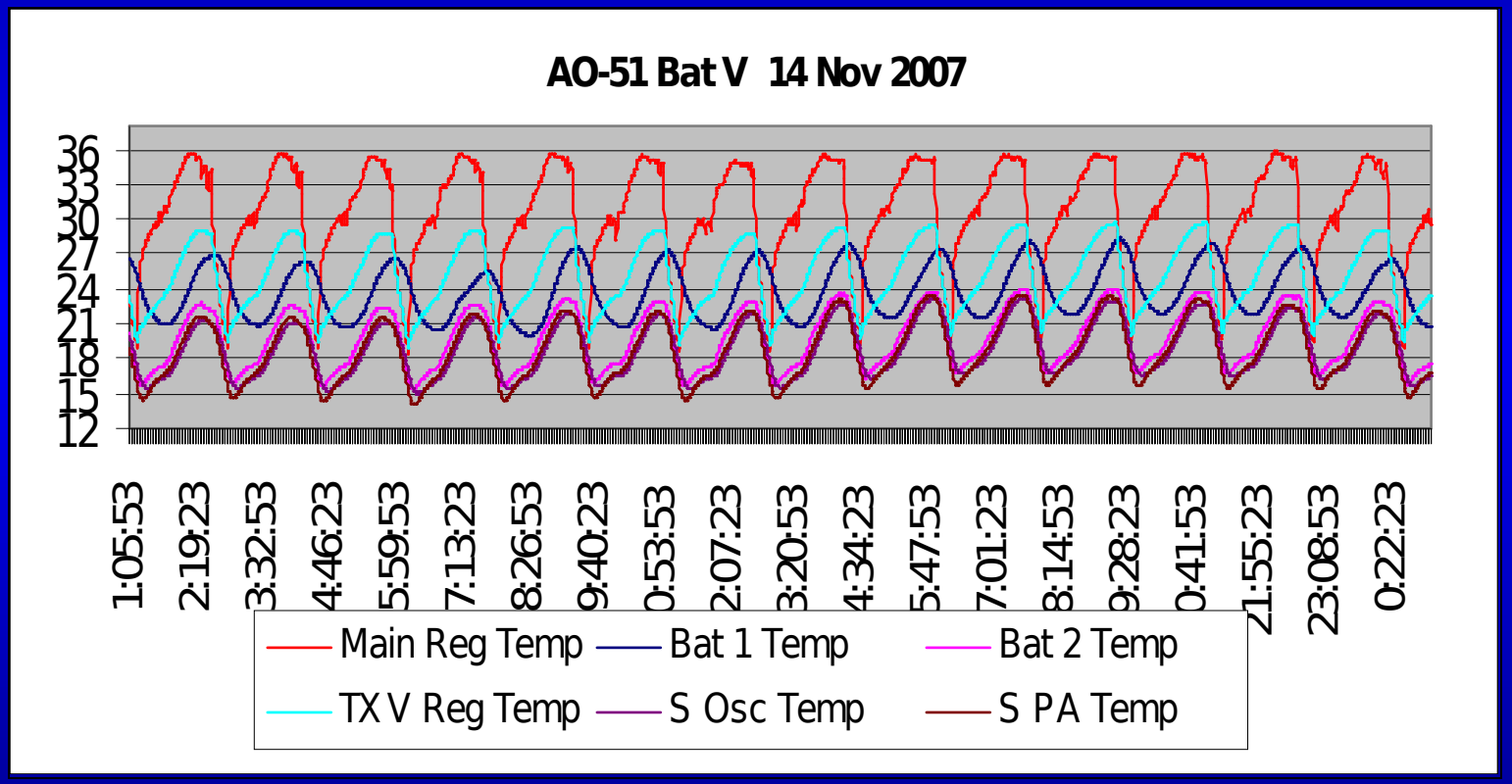


AO-51 Sun Distances

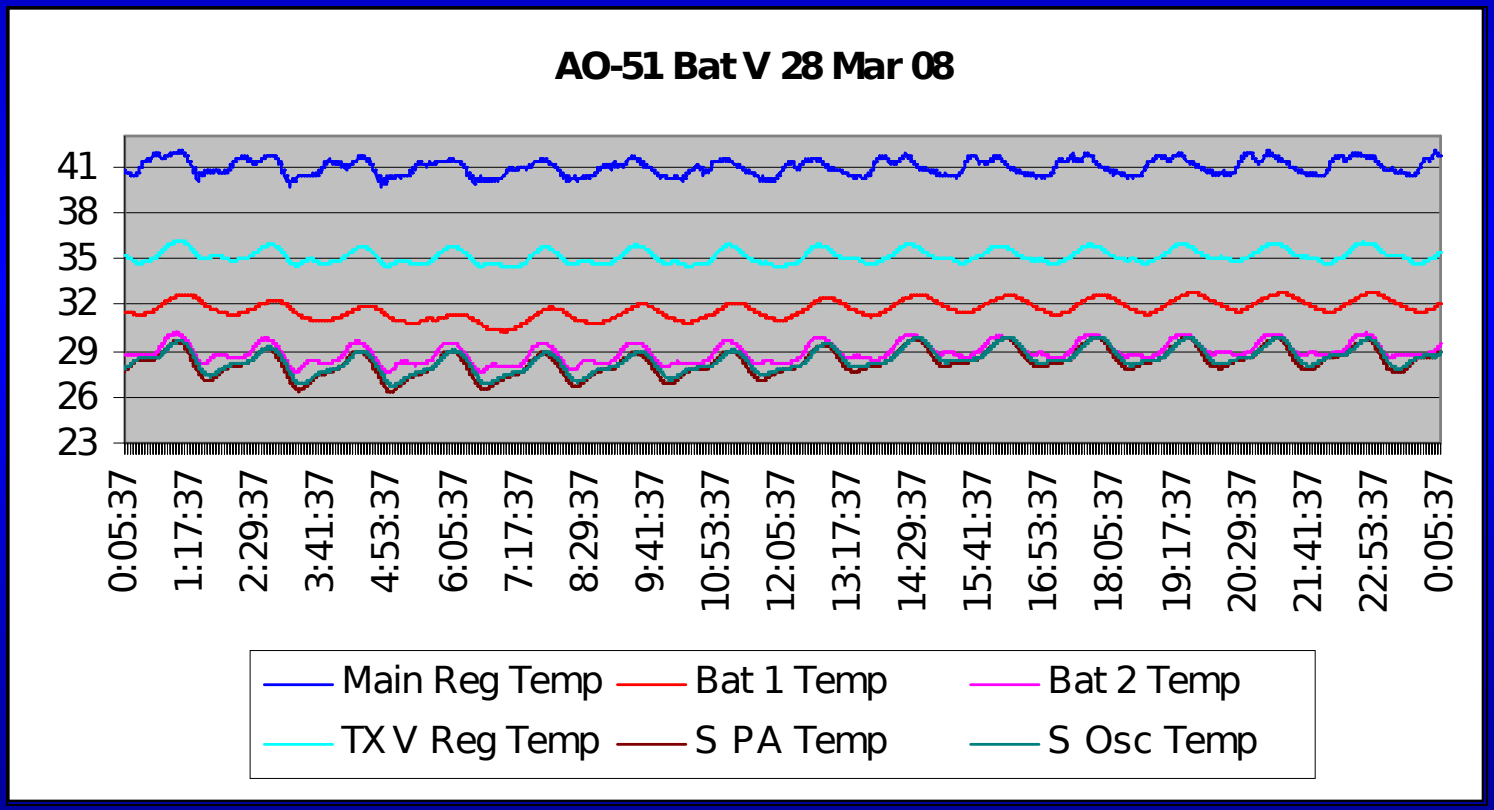


~3 million miles difference

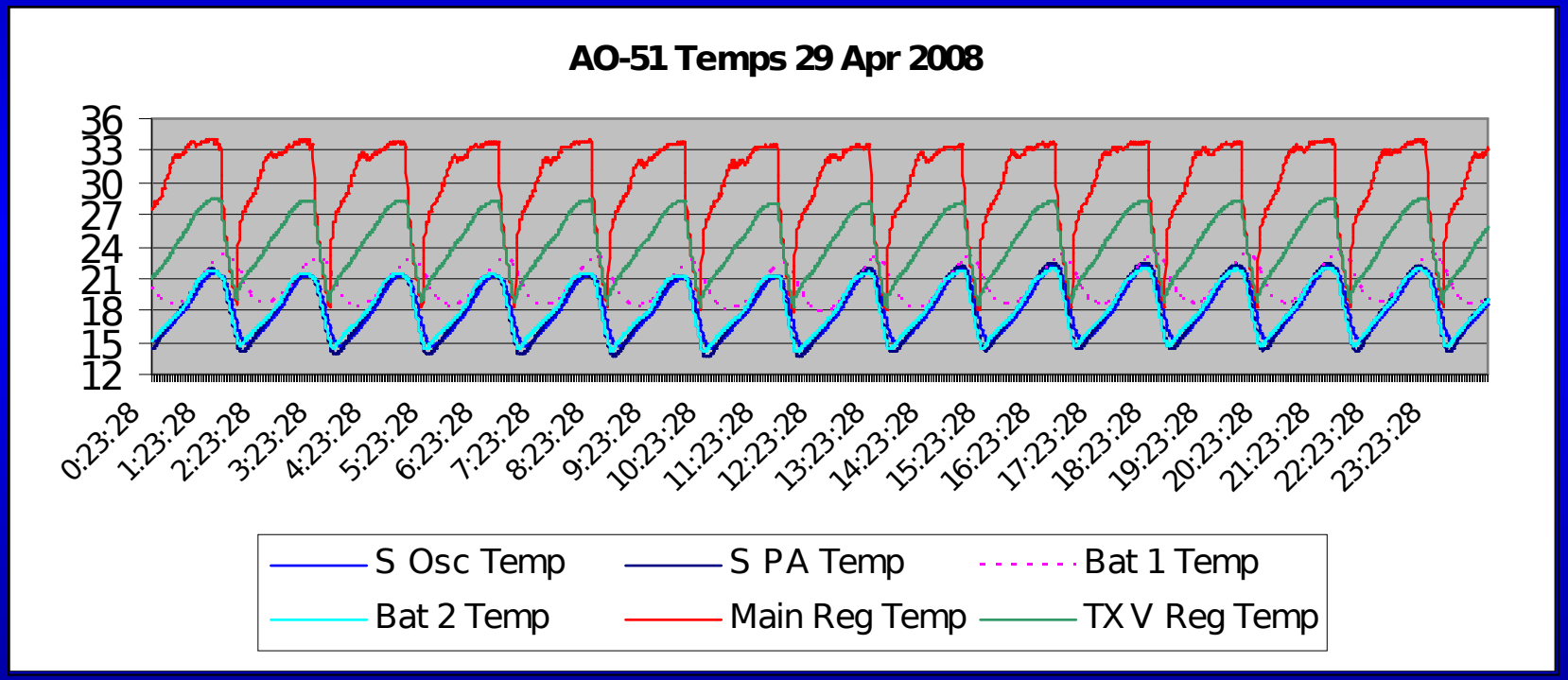
AO-51 Fall Temps before no eclipse
TX 0.88W



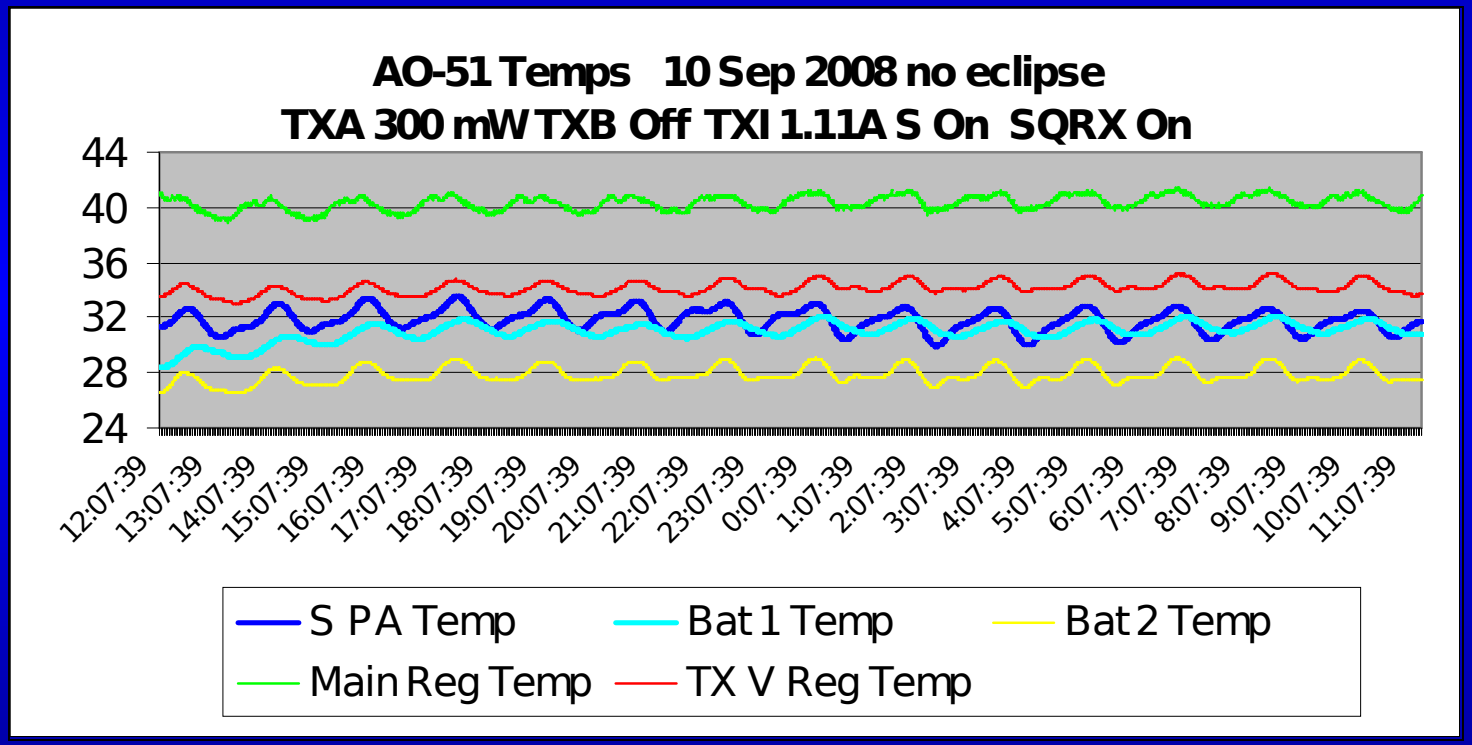
AO-51 Spring Temps during no eclipse
TX 1.42W



AO-51 temps post no eclipse TX 0.97W



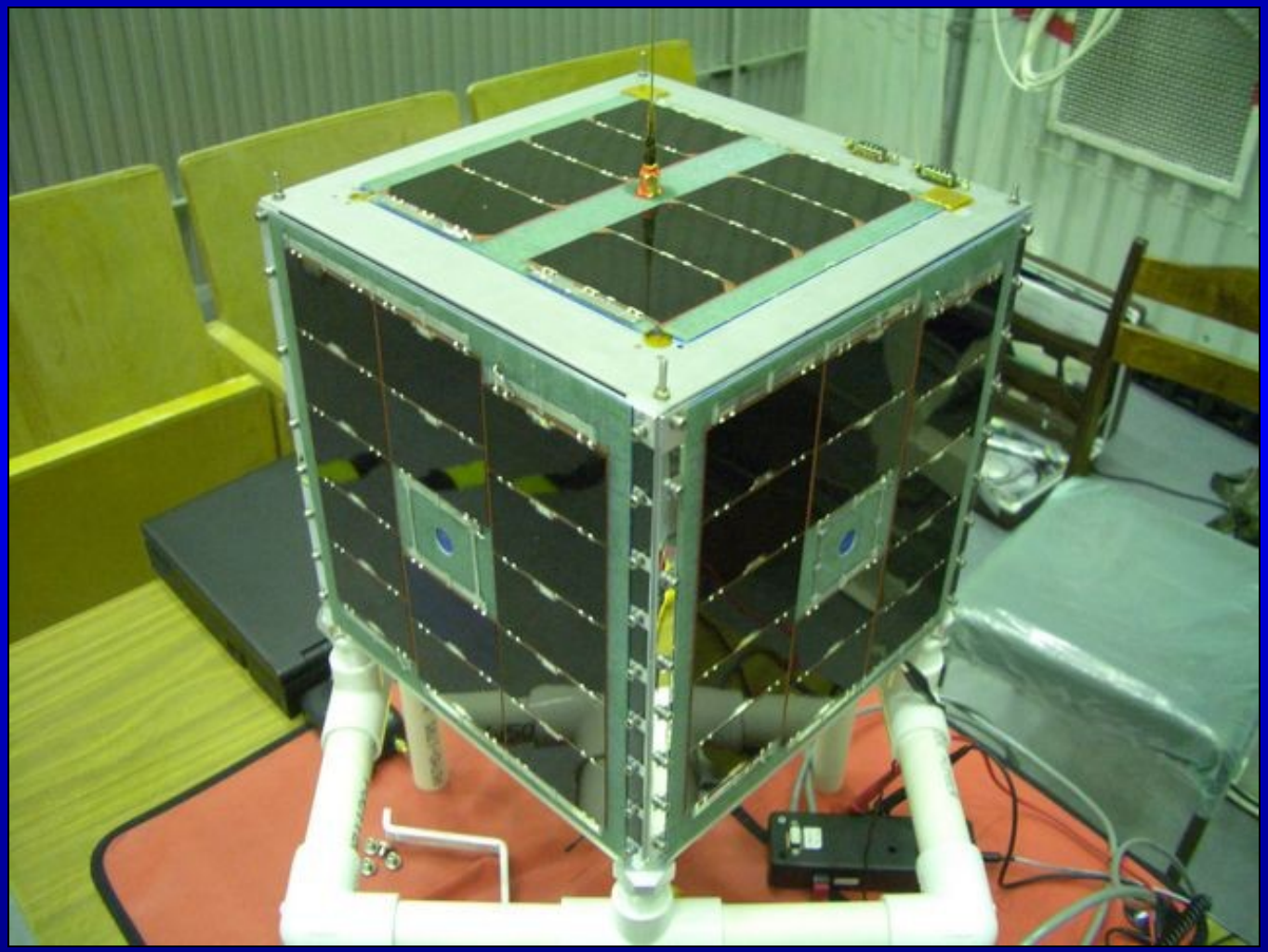
AO-51 Temps second no eclipse TX 1.1 W



AO-51 Temperature Summary

		Batt 1	Batt 2 (chassis)	Main Reg	TX V Reg
Fall 2008	**No eclipse**	**31**	**28**	**41**	**35**
Summer 2008	**eclipse**	**20**	**16**	**24**	**20**
Spring 2008	eclipse	20	12	26	23
Winter 2008	No eclipse	32	31	44	37
Fall 2007	eclipse	20	19	27	25
Summer 2007	eclipse	14	12	18	15
Winter	eclipse	20	15	23	20

AO-51 Array Current



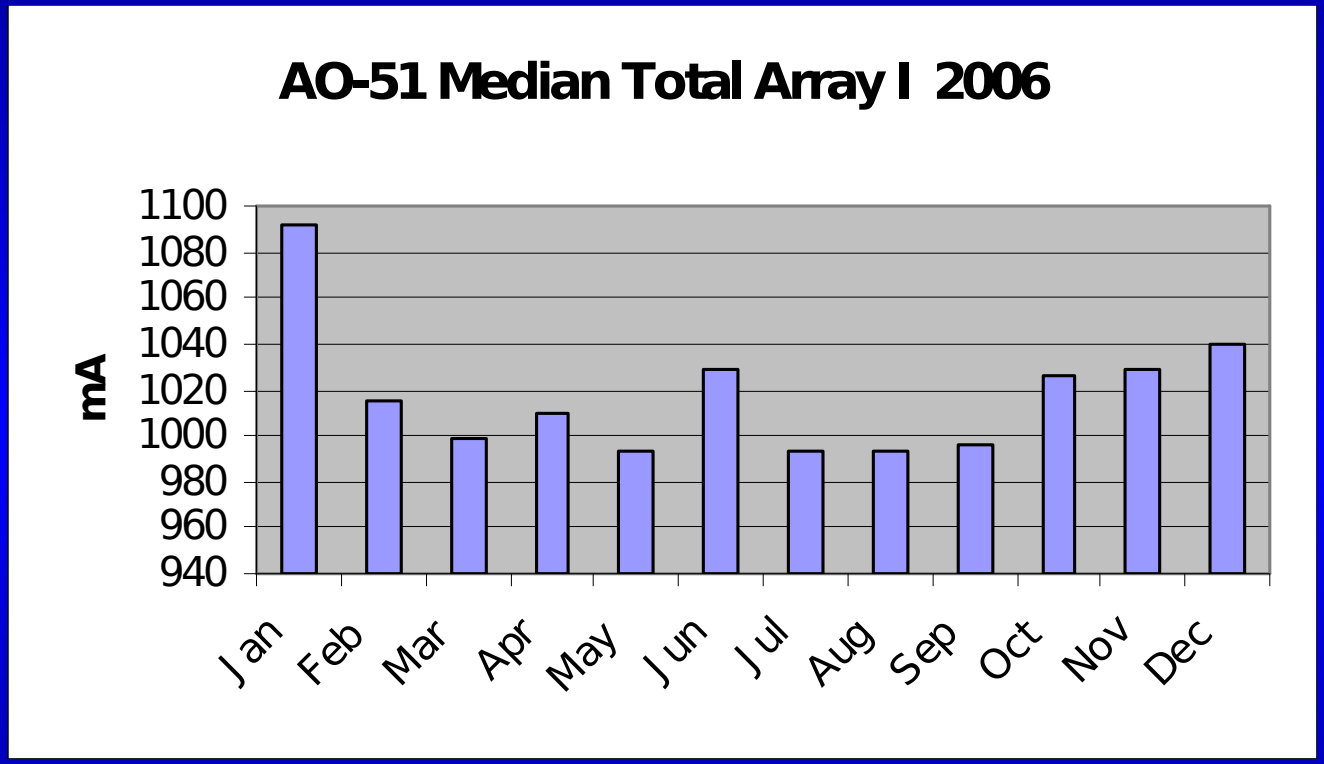
14 cells on

±X & ±Y

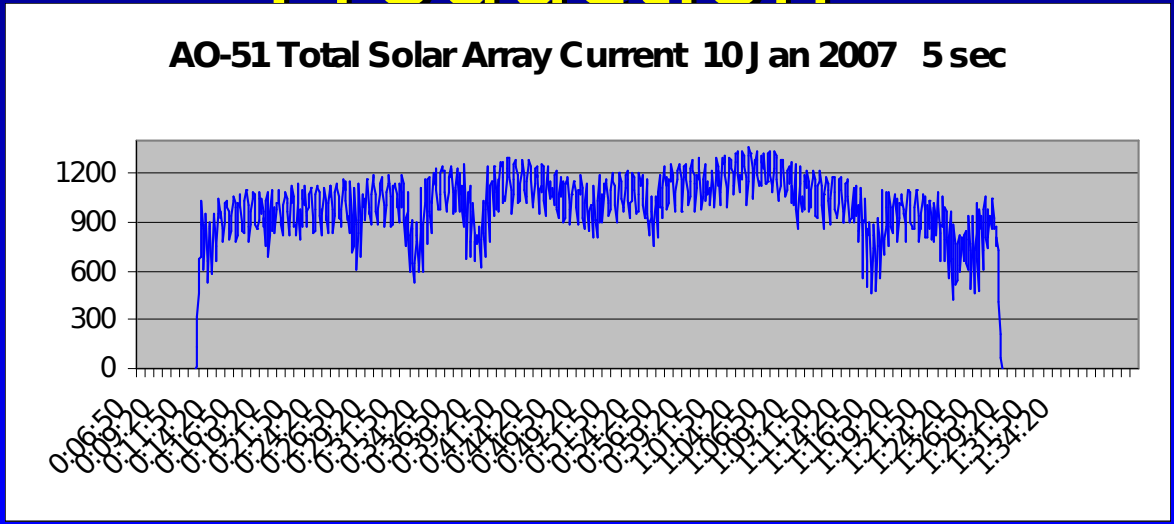
7 cells on ±Z

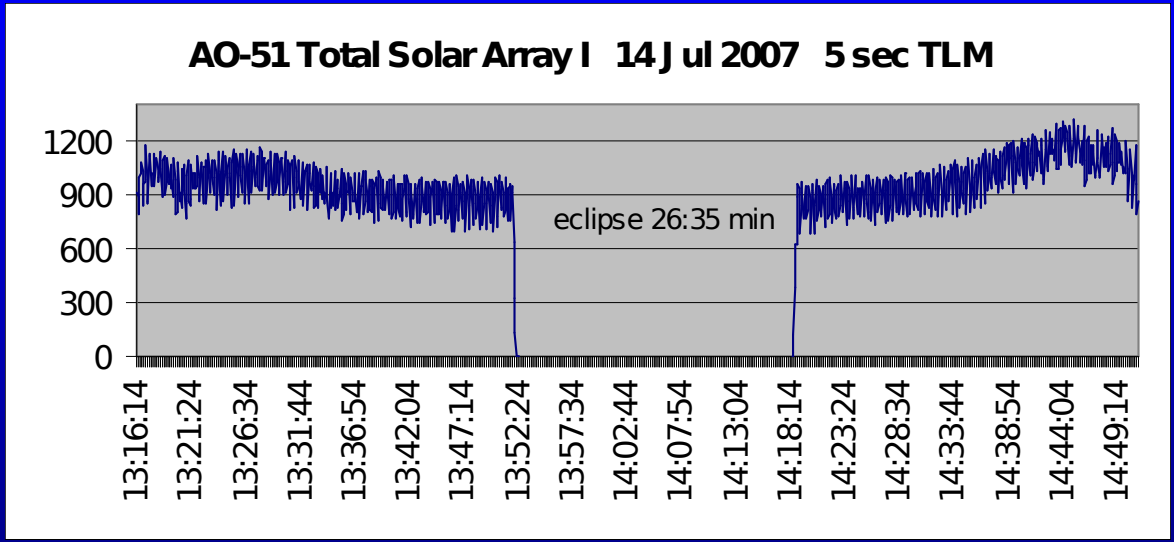
~20W

2006 AO-51 Solar Production

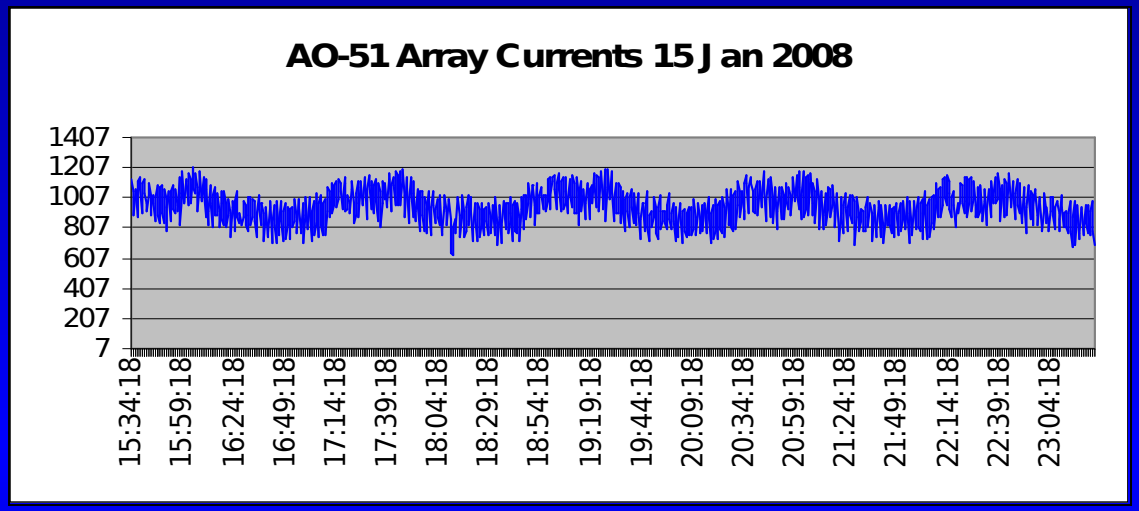


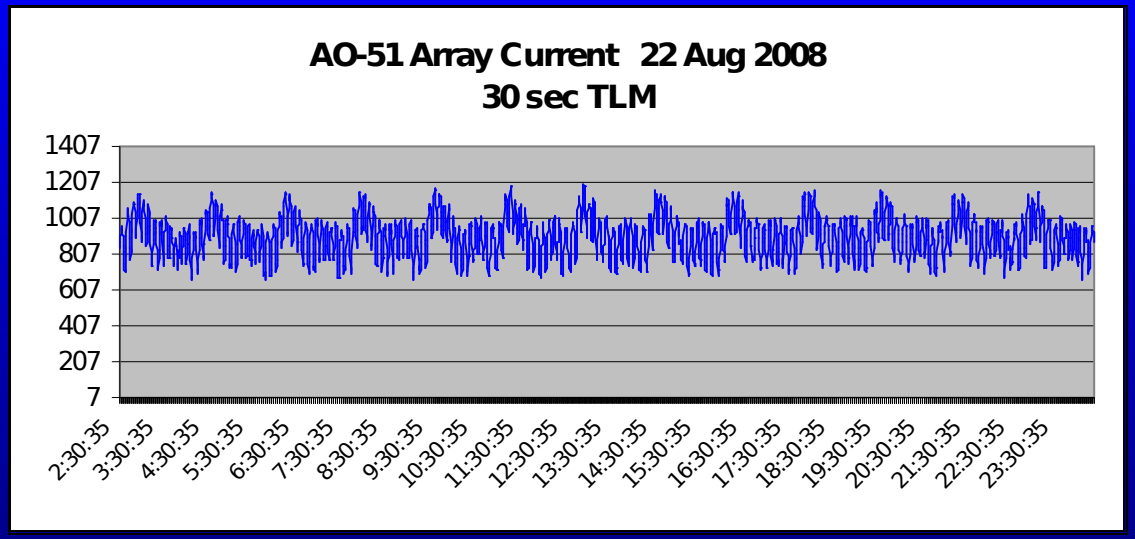
2007 AO-51 Solar Production



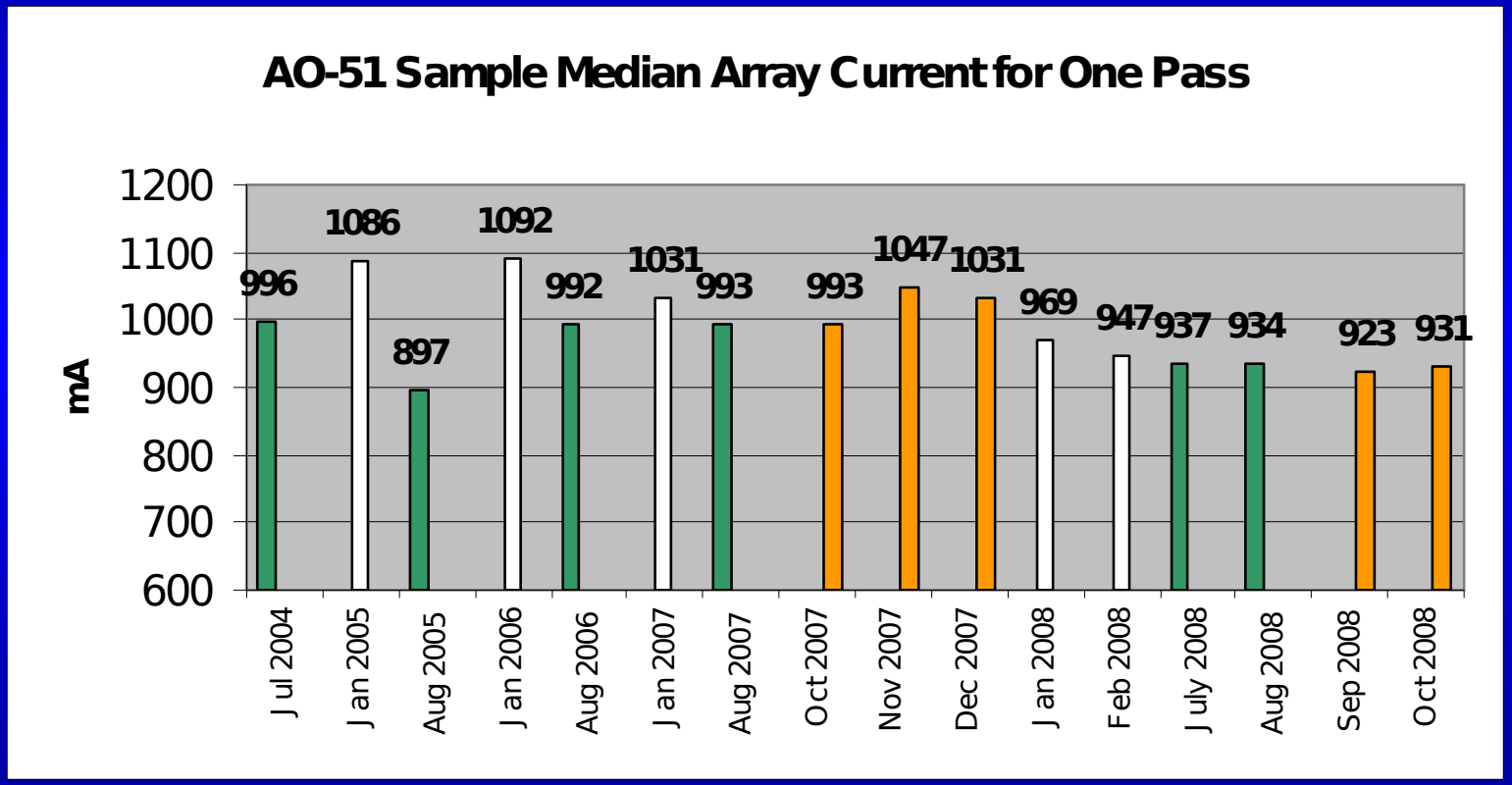


2008 No Eclipse AO-51 Solar Production

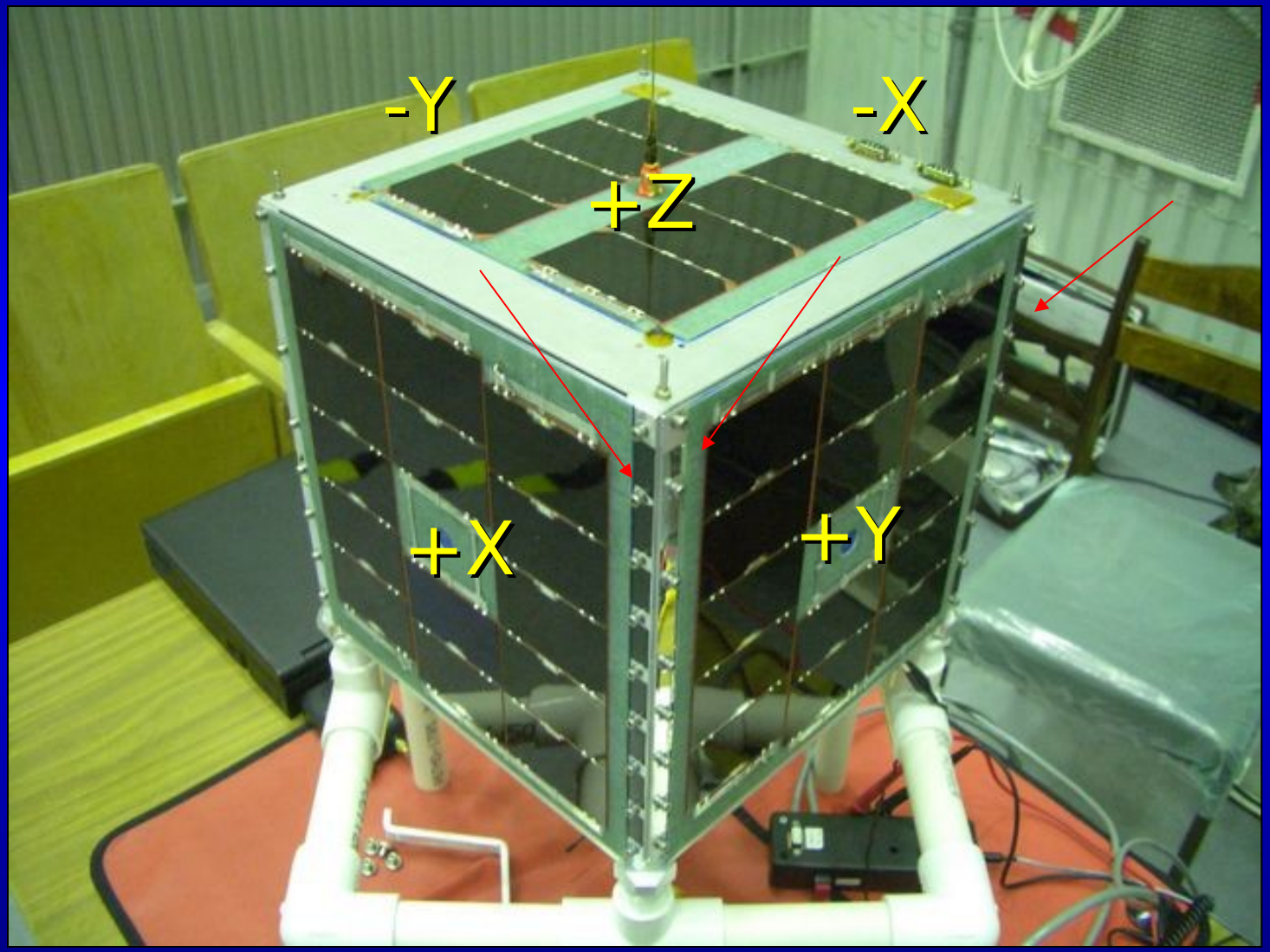




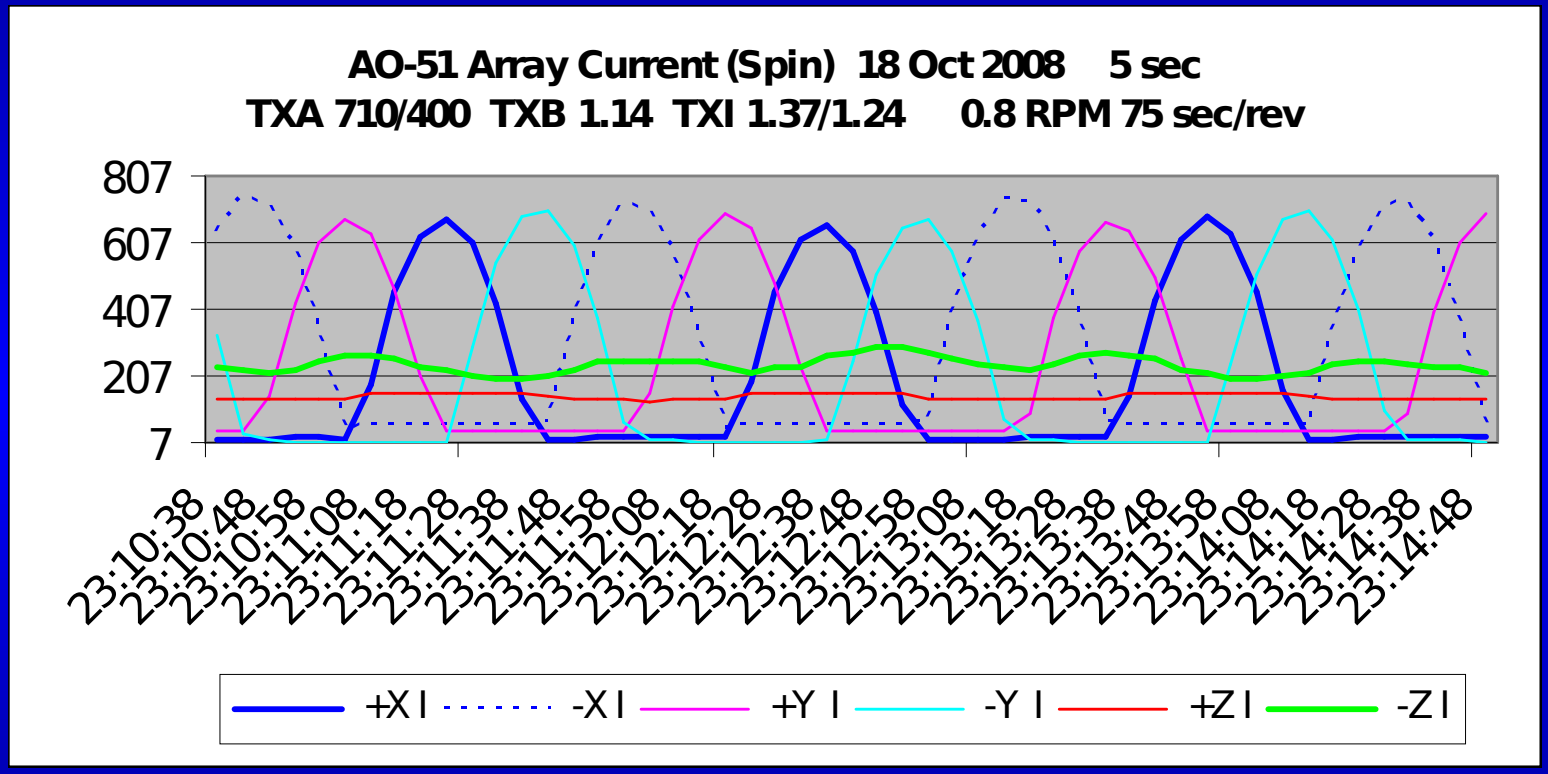
AO-51 Solar Production Summary



AO-51 Spin

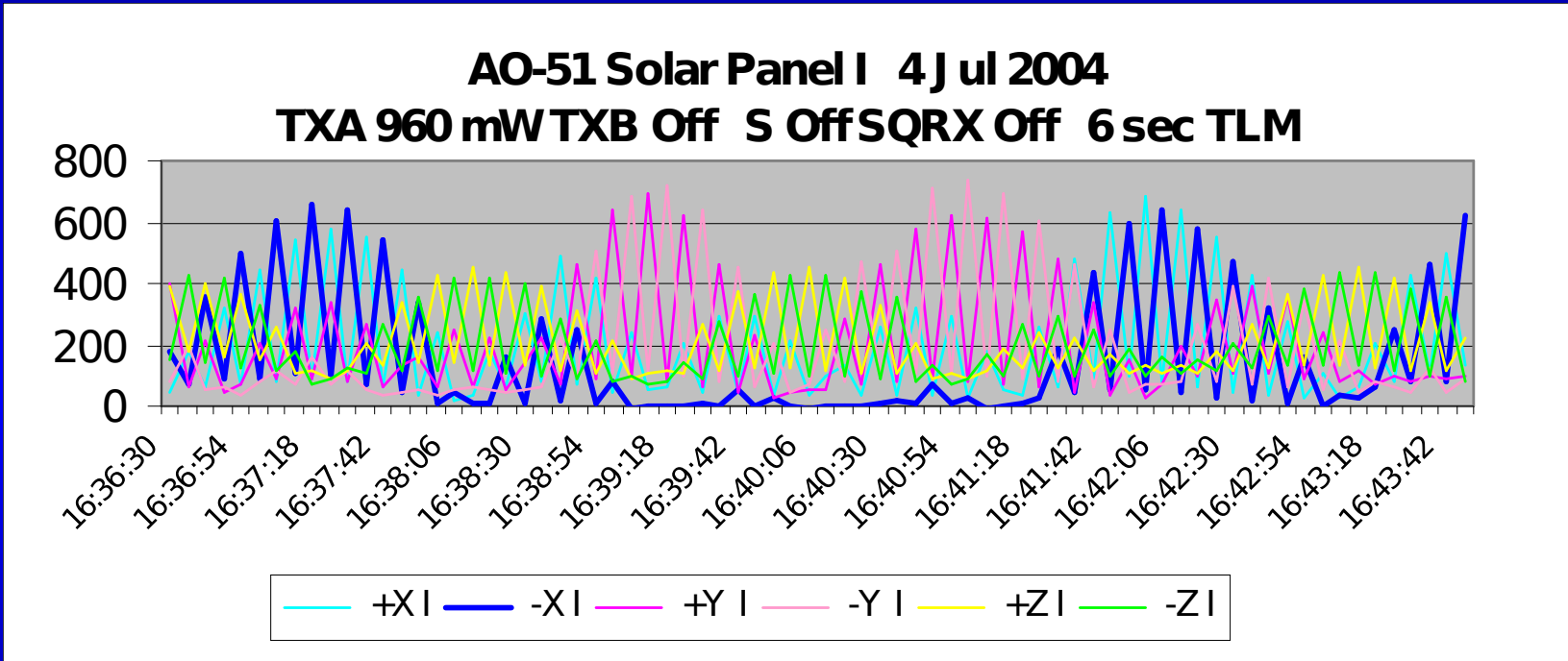


AO-51 Spin Telemetry



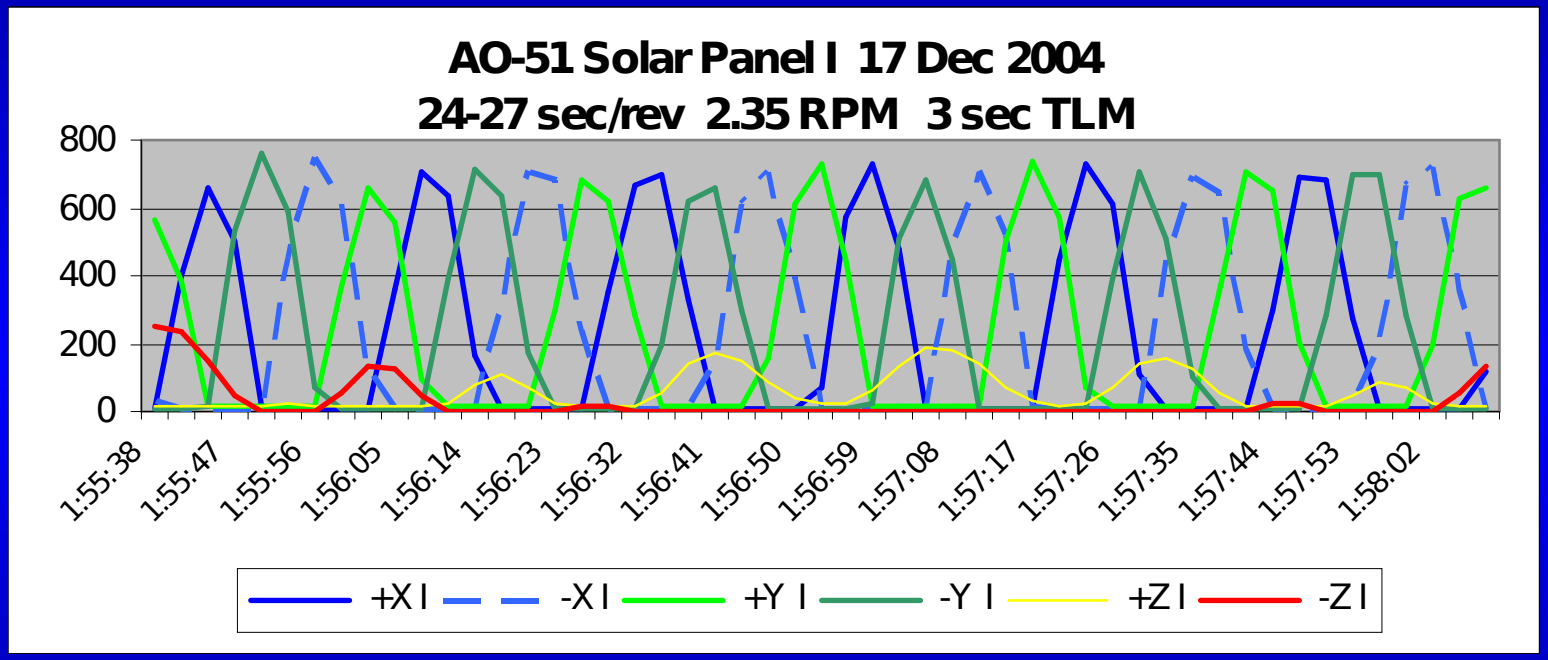
very good spin sample

AO-51 Spin Soon After Launch

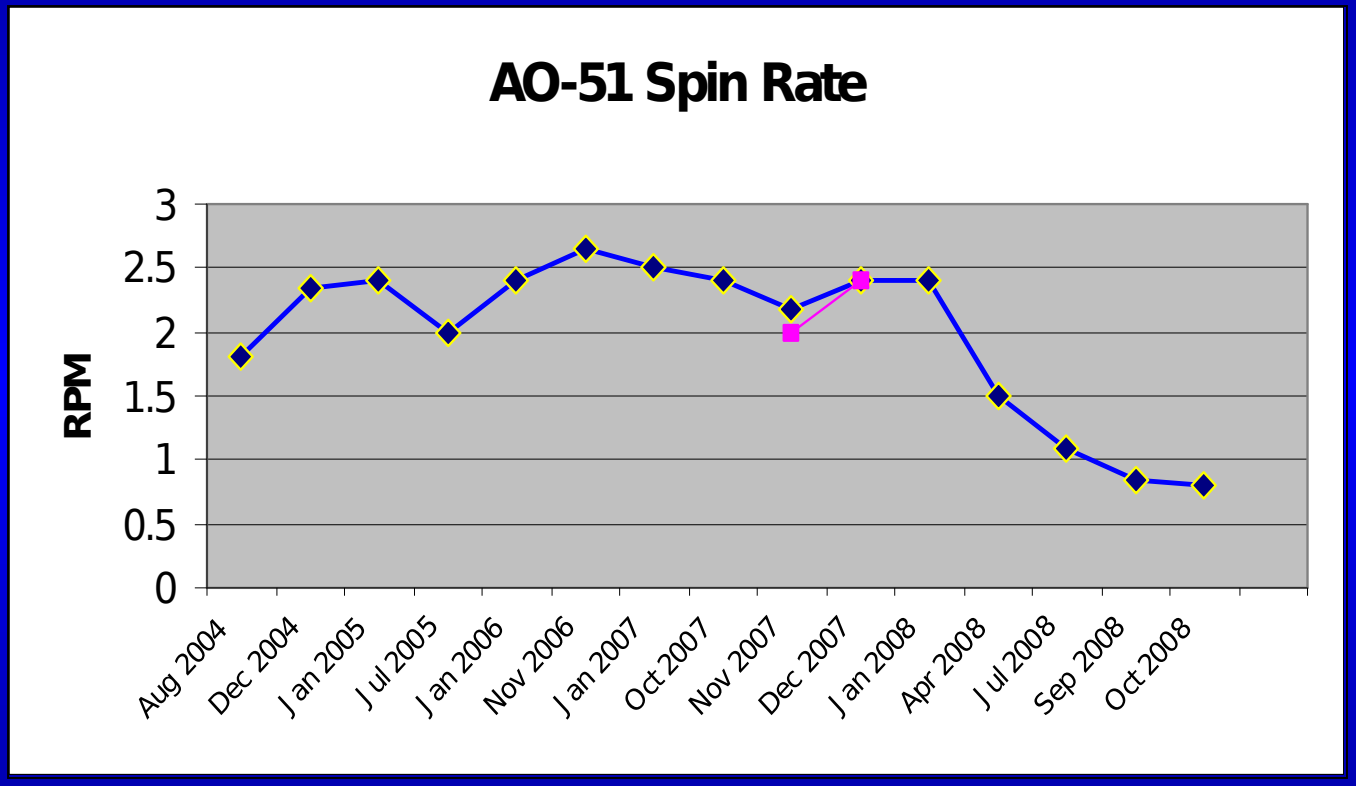


unusable spin sample

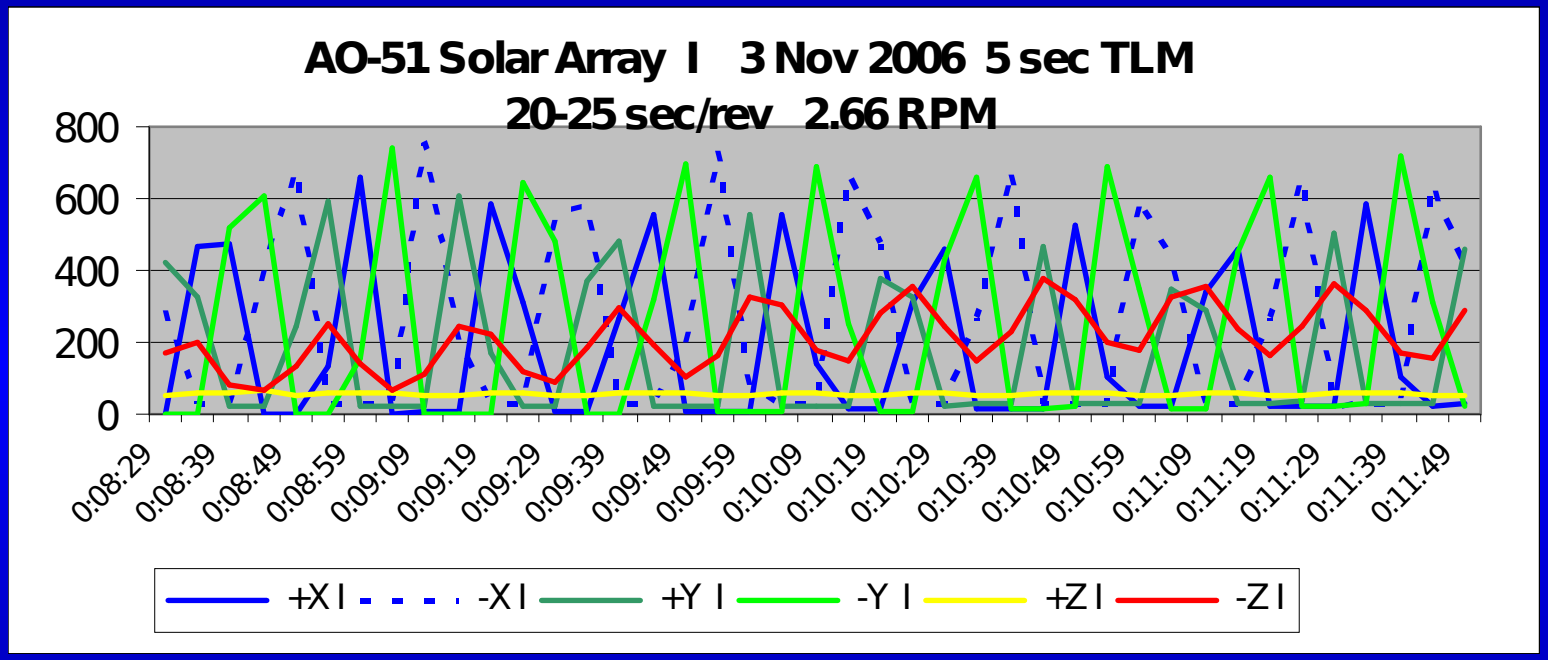
AO-51 Spin @ 6 months



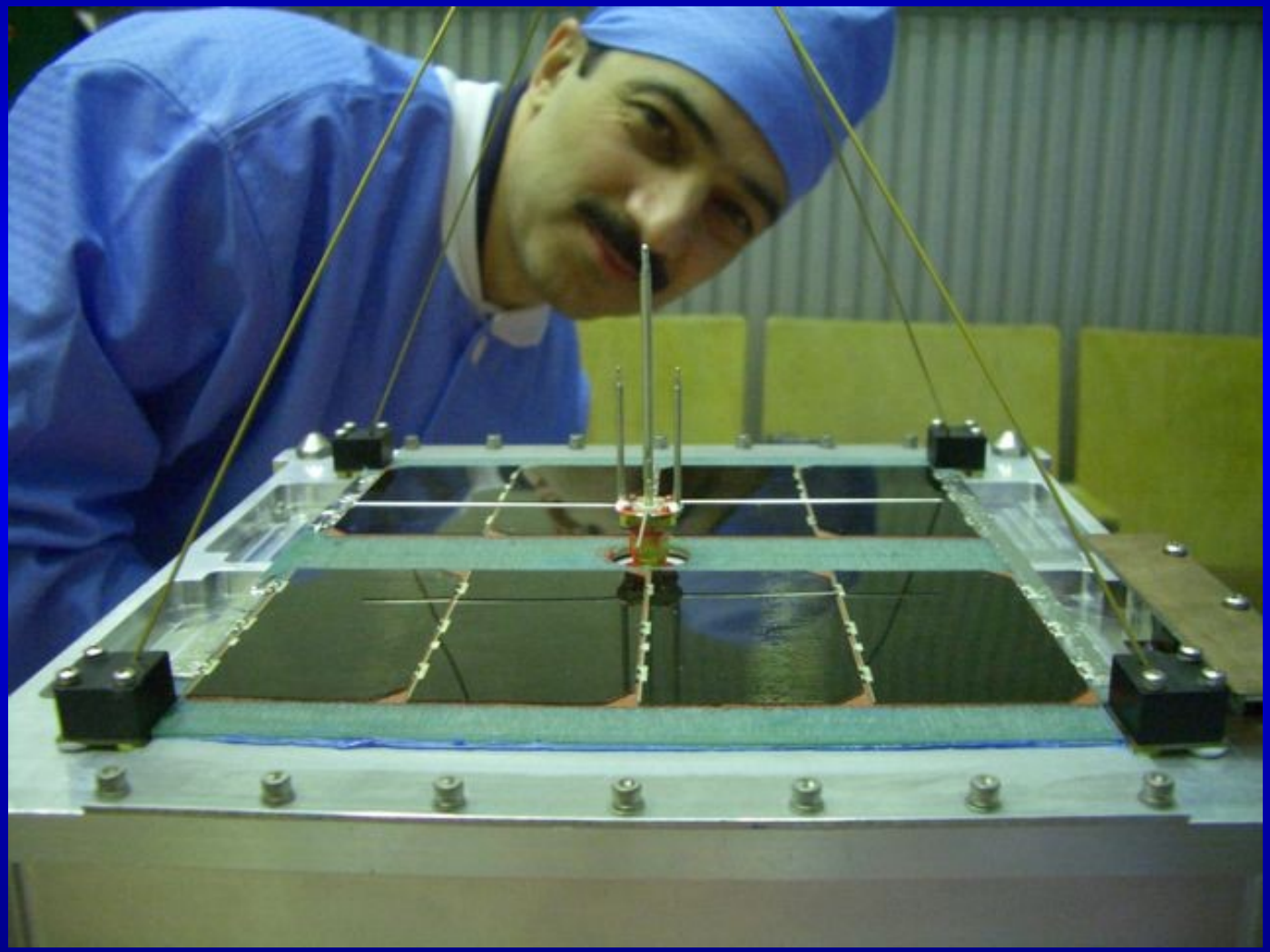
AO-51 Spin


AO-51 Spin Rate
RPM
3
2.5
2
1.5
1
0.5
0
Aug 2004
Dec 2004
Jan 2005
Jul 2005
Jan 2006
Nov 2006
Jan 2007
Oct 2007
Nov 2007
Dec 2007
Jan 2008
Apr 2008
Jul 2008
Sep 2008
Oct 2008

AO-51 Wobble


AO-51 Solar Array I 3 Nov 2006 5 sec TLM
20-25 sec/rev 2.66 RPM
800
600
400
200
0
0:08:29
0:08:39
0:08:49
0:08:59
0:09:09
0:09:19
0:09:29
0:09:39
0:09:49
0:09:59
0:10:09
0:10:19
0:10:29
0:10:39
0:10:49
0:10:59
0:11:09
0:11:19
0:11:29
0:11:39
0:11:49
+X I
-X I
+Y I
-Y I
+Z I
-Z I

AO-51 70cm, L & S Antennas



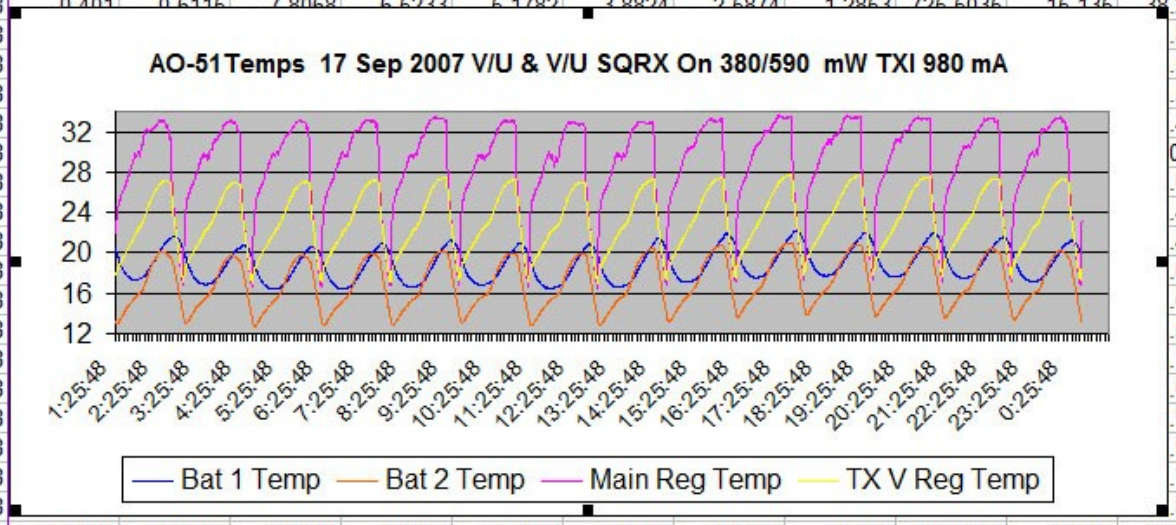
Summary

- AO-51 will spend a good deal of the next few years in a no eclipse orbit
- During no eclipse orbits, the satellite tends to track the grey line
- No eclipse periods mean higher TX power
- No eclipse periods mean a warmer satellite
- AO-51 spin rate is decreasing – what will it do?

Any Volunteers to help study the telemetry?

Wd091700

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Echo Time	TX A Powe	TX B Powe	Bat V	Cell 5 V	Cell 4 V	Cell 3 V	Cell 2 V	Cell 1 V	Total Array	Total Array	+X I	-X I
2	1:25:48	0.401	0.6298	7.9166	6.613	5.2541	3.942	2.6291	1.3094	981.1517	15.147	465.4788	39.5
3	1:26:18	0.401	0.6298	7.7824	6.5127	5.1655	3.8761	2.5825	1.2853	761.2585	15.135	645.9507	40.5
4	1:26:48	0.401	0.6115	7.9471	6.6447	5.2794	3.9577	2.6438	1.3167	993.666	15.147	475.0784	39.5
5	1:27:18	0.401	0.6115	7.8068	6.5233	5.1782	3.8824	2.5874	1.2863	725.5036	15.136	38.2979	41.5
6	1:27:48											.8185	424.2
7	1:28:18											.5382	718.0
8	1:28:48											.5382	632.9
9	1:29:18											.4981	285.8
10	1:29:48											0.536	32.6
11	1:30:18											.0784	31.6
12	1:30:48											.4702	29.6
13	1:31:18											.4777	27.6
14	1:31:48											.0176	24.7
15	1:32:18											.6572	445.0
16	1:32:48											.5371	716.0
17	1:33:18											.1378	638.9
18	1:33:48											.0977	230.4
19	1:34:18											.9311	12.
20	1:34:48											.9139	13.
21	1:35:18											.7094	11.8
22	1:35:48											.8381	10.8
23	1:36:18	0.3872	0.5935	7.9471	6.6499	5.2794	3.9577	2.6365	1.307	752.3197	15.135	63.2568	8.8
24	1:36:48	0.3872	0.5935	8.0568	6.7396	5.3554	4.0173	2.6831	1.3335	1049.086	15.159	59.417	420.3
25	1:37:18	0.3872	0.596	8.0812	6.7555	5.368	4.0205	2.6831	1.3311	859.5847	15.147	59.417	699.2
26	1:37:48	0.3872	0.5935	7.9897	6.6816	5.3132	3.986	2.6634	1.3215	995.4537	15.159	58.457	626.
27	1:38:18	0.3872	0.5935	8.1422	6.8135	5.4102	4.0582	2.7051	1.3432	954.3355	15.147	40.2178	209.6
28	1:38:48	0.385	0.596	7.9715	6.671	5.3005	3.9765	2.6536	1.3167	936.458	15.147	197.6508	-3.9
29	1:39:18	0.3872	0.5935	8.2154	6.8716	5.4608	4.0958	2.7346	1.3577	1034.784	15.159	620.0319	-3.9



Questions?